

Please check the examination details below before entering your candidate information

Candidate surname		Other names	
Centre Number		Candidate Number	

Pearson Edexcel International Advanced Level

Monday 02 June 2025

Morning (Time: 1 hour 45 minutes)

Paper reference **WCH15/01**

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

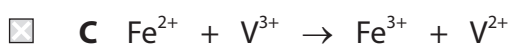
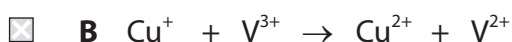
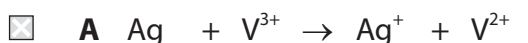
Answer ALL the questions in this section.

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 Which reaction is thermodynamically feasible under standard conditions?

Use your Data Booklet.



(Total for Question 1 = 1 mark)

- 2 In a redox titration, $0.0500 \text{ mol dm}^{-3}$ potassium manganate(VII) is titrated against 25.0 cm^3 of a solution containing iron(II) ions.



The mean titre of potassium manganate(VII) is 18.95 cm^3 .

- (a) What colour change is seen at the end-point?

(1)



(b) What is the concentration, in mol dm^{-3} , of the Fe^{2+} ions in the solution?

(1)

- ☐ **A** 1.90×10^{-1}
- ☐ **B** 7.58×10^{-3}
- ☐ **C** 4.74×10^{-3}
- ☐ **D** 1.90×10^{-4}

(c) What is the percentage error in a single titre of 18.95 cm^3 ?

(1)

[The uncertainty in a single burette reading is $\pm 0.05 \text{ cm}^3$]

- ☐ **A** $\pm 0.20\%$
- ☐ **B** $\pm 0.26\%$
- ☐ **C** $\pm 0.40\%$
- ☐ **D** $\pm 0.53\%$

(d) Which row shows the correct changes in oxidation states?

(1)

	manganese	iron
☐ A	II $\rightarrow$ VII	III $\rightarrow$ II
☐ B	II $\rightarrow$ VII	II $\rightarrow$ III
☐ C	VII $\rightarrow$ II	III $\rightarrow$ II
☐ D	VII $\rightarrow$ II	II $\rightarrow$ III

(Total for Question 2 = 4 marks)

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

3 Which reaction occurs at an electrode in a hydrogen-oxygen fuel cell?

- ☐ A $\text{O}_2(\text{g}) + 2\text{H}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{l})$
- ☐ B $\text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + 4\text{e}^- \rightarrow 4\text{OH}^-(\text{aq})$
- ☐ C $4\text{H}^+(\text{aq}) + 4\text{OH}^-(\text{aq}) \rightarrow 4\text{H}_2\text{O}(\text{l})$
- ☐ D $\text{H}_2\text{O}(\text{l}) + 2\text{OH}^-(\text{aq}) \rightarrow 2\text{H}_2(\text{g}) + 1\frac{1}{2}\text{O}_2(\text{g}) + 2\text{e}^-$

(Total for Question 3 = 1 mark)

4 What is the electronic configuration of a Zn^{2+} ion?

- ☐ A $[\text{Ar}] 3\text{d}^{10}$
- ☐ B $[\text{Ar}] 3\text{d}^{10} 4\text{s}^2$
- ☐ C $[\text{Ar}] 3\text{d}^9 4\text{s}^1$
- ☐ D $[\text{Ar}] 3\text{d}^8 4\text{s}^2$

(Total for Question 4 = 1 mark)

5 What is the colour of an aqueous solution of V^{2+} ions?

- ☐ A blue
- ☐ B green
- ☐ C purple
- ☐ D yellow

(Total for Question 5 = 1 mark)

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



6 Which is **incorrect** for H_2O , OH^- and NH_3 ?

- ☐ A all can act as bidentate ligands
- ☐ B all can act as electron pair donors
- ☐ C all can form dative covalent bonds
- ☐ D all can take part in complex ion formation

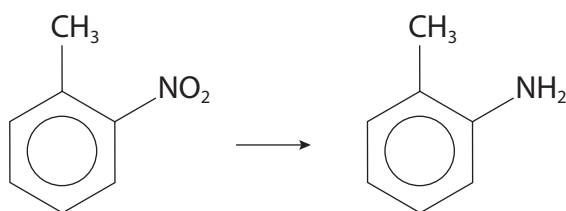
(Total for Question 6 = 1 mark)

7 Which product forms when butylamine reacts with ethanoyl chloride?

- ☐ A ethanamide
- ☐ B butanamide
- ☐ C *N*-butylethanamide
- ☐ D *N*-ethylbutanamide

(Total for Question 7 = 1 mark)

8 Which are the reagents and conditions for the reaction shown?

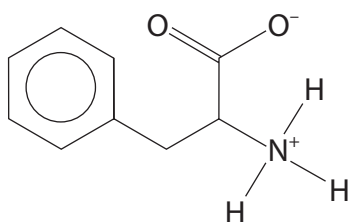


- ☐ A $\text{K}_2\text{Cr}_2\text{O}_7$, H^+ and reflux
- ☐ B LiAlH_4 in dry ether
- ☐ C H_2 gas at high temperature
- ☐ D Sn, concentrated HCl and reflux

(Total for Question 8 = 1 mark)

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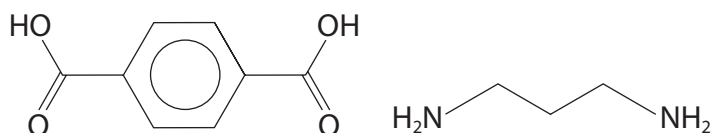
9 At what pH would the amino acid phenylalanine have the structure shown?



- ☐ A pH 2
- ☐ B pH 6
- ☐ C pH 10
- ☐ D pH 14

(Total for Question 9 = 1 mark)

10 Which is the repeat unit of the polymer formed from the monomers shown?

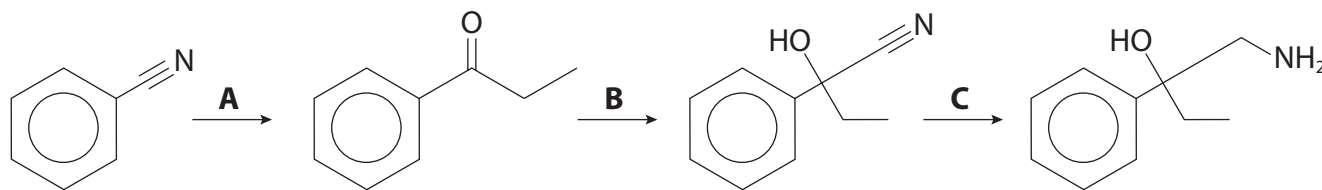


- ☐ A
- ☐ B
- ☐ C
- ☐ D

(Total for Question 10 = 1 mark)



11 A reaction scheme is shown.



(a) Which is the name of the functional group that is replaced in step **A**?

(1)

- ☐ **A** phenyl
- ☐ **B** nitrile
- ☐ **C** amine
- ☐ **D** amide

(b) What type of reaction mechanism is taking place in step **B**?

(1)

- ☐ **A** electrophilic addition
- ☐ **B** electrophilic substitution
- ☐ **C** nucleophilic addition
- ☐ **D** nucleophilic substitution

(c) What are the reagents used in step **B**?

(1)

- ☐ **A** KCN and NaOH
- ☐ **B** HCN and KCN
- ☐ **C** HCl and KNO₂
- ☐ **D** HNO₃ and H₂SO₄

(d) What is the percentage of carbon, by mass, in the final product?

(1)

[*M_r* of the final product = 165]

- ☐ **A** 58.2%
- ☐ **B** 65.5%
- ☐ **C** 72.7%
- ☐ **D** 80.0%

(Total for Question 11 = 4 marks)

12 A substituted benzene compound has the general formula C_nH_{2n-6} .

When completely combusted, 0.025 mol of the compound produced 11.0 g of CO_2 .

Which could be the M_r of the compound?

- ☐ A 64
- ☐ B 78
- ☐ C 128
- ☐ D 134

(Total for Question 12 = 1 mark)

13 This question is about branched alkanes.

(a) How many peaks are there in the ^{13}C NMR spectrum of 2,2-dimethylpropane?

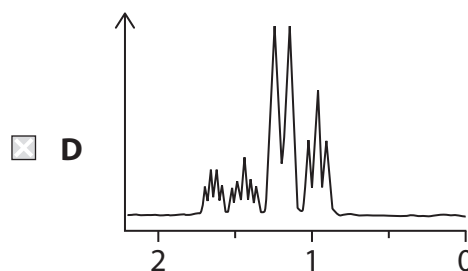
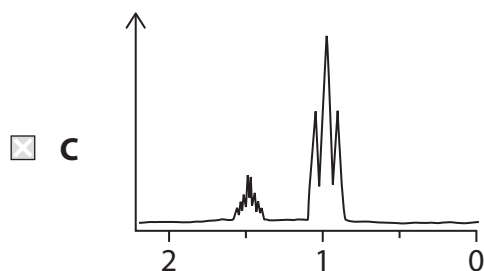
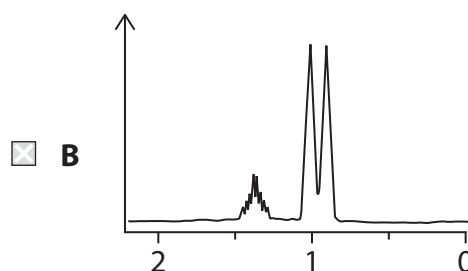
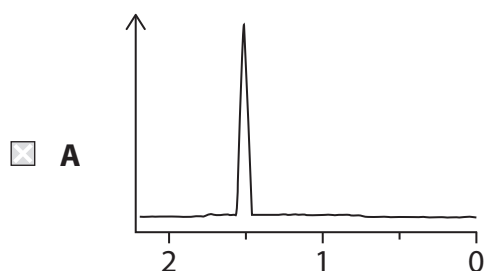
(1)

- ☐ A one
- ☐ B two
- ☐ C three
- ☐ D five

(b) Four students sketched the high-resolution proton NMR spectrum of 2,3-dimethylbutane.

Which sketch is most likely to be correct?

(1)



(Total for Question 13 = 2 marks)

TOTAL FOR SECTION A = 20 MARKS

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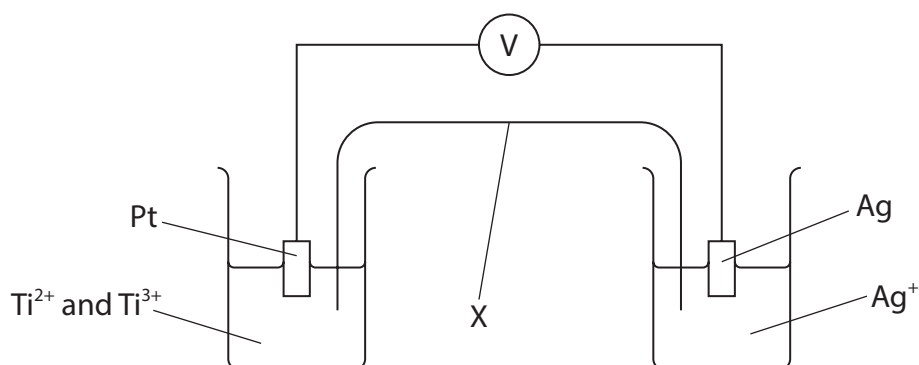
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SECTION B

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

14 This question is about the electrochemical cell shown.



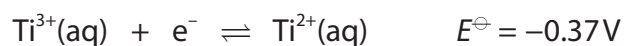
(a) State the name and purpose of part **X**.

(2)

(b) Draw a cell diagram for this system.

(2)

(c) The electrode system for the titanium ions is shown.



Calculate the $E_{\text{cell}}^{\ominus}$ value. Use your Data Booklet.

(2)

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- (3)

(Total for Question 14 = 9 marks)



15 *Cis*-platin, $\text{PtCl}_2(\text{NH}_3)_2$, is used in cancer treatment as it inhibits DNA replication.

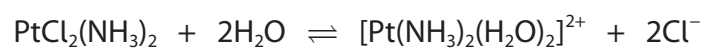
(a) State the shape of the *cis*-platin complex.

(1)

(b) Draw the isomer *trans*-platin.

(1)

(c) In human cells, the two chloride ions are replaced by water molecules in a ligand exchange reaction as shown.

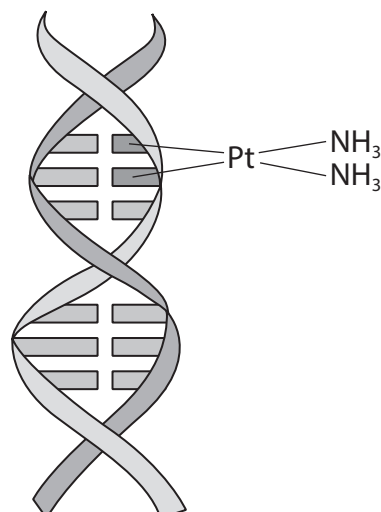


Suggest why this occurs.

(2)



(d) DNA forms two dative covalent bonds with *cis*-platin as shown.

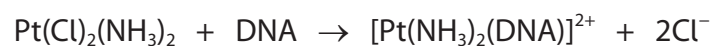


(i) DNA acts as a ligand in the formation of the complex shown in the diagram.

Name this type of ligand.

(1)

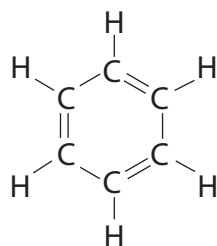
(ii) Explain, by considering the equation shown, why this process is thermodynamically feasible.



(2)

(Total for Question 15 = 7 marks)

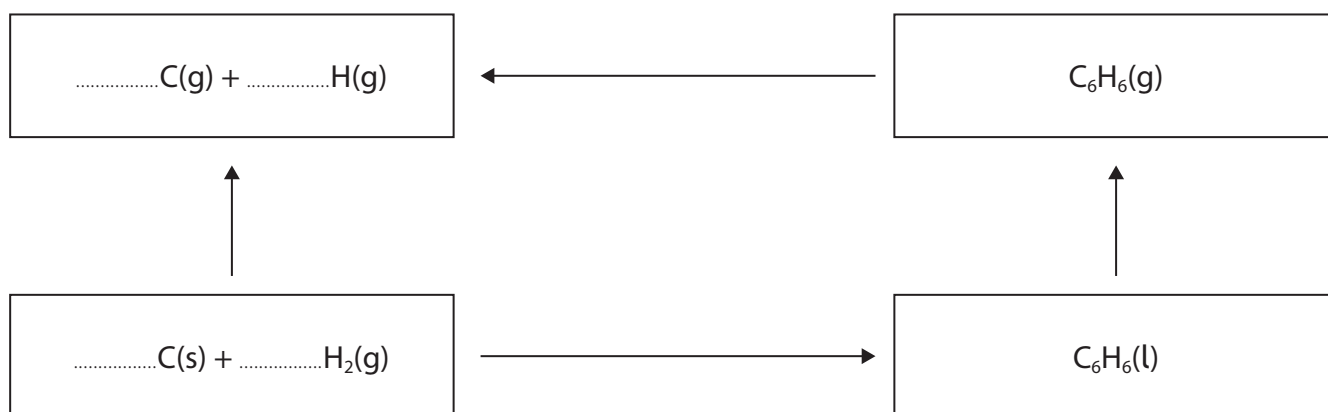
16 In 1865, Kekulé proposed a cyclic structure for benzene, C_6H_6 .



(a) An incomplete Hess cycle is shown.

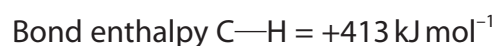
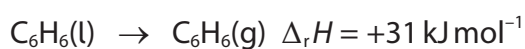
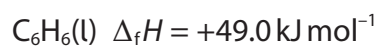
(i) Complete the cycle by adding balancing numbers.

(1)



(ii) Calculate the mean carbon-carbon bond enthalpy in benzene, using your completed cycle and the data shown.

(2)



- (iii) Explain why the bond enthalpy value calculated in (a)(ii) is not the exact mean of the carbon-carbon double bond and carbon-carbon single bond enthalpies that would be expected from the Kekulé structure.

Bond enthalpy C—C = +347 kJ mol⁻¹

Bond enthalpy C=C = +612 kJ mol⁻¹

(2)

- (b) Describe how all the carbon-carbon bonds in benzene are formed.

(2)

- (c) State one chemical property and one physical property of benzene which would **not** be shown by the compound with the Kekulé structure.

(2)

(Total for Question 16 = 9 marks)

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17 Trimethylamine, $\text{C}_3\text{H}_9\text{N}$, is the main reason rotting fish smells so bad. Trimethylamine is present in the blood and other fluids of many animals but it has higher concentrations in fish.

(a) (i) Draw the **skeletal** structure of trimethylamine.

(1)

(ii) Identify the class of amine to which trimethylamine belongs.

(1)

(iii) Trimethylamine is a gas at room temperature but readily dissolves in water.

Draw a diagram of the intermolecular force that leads to trimethylamine being soluble in water.

Include relevant dipoles and lone pairs.

(2)

(iv) An aqueous solution of trimethylamine is alkaline.

Write an **ionic** equation to show how trimethylamine acts as a base.

State symbols are not required.

(1)

(b) When trimethylamine oxidises, it forms trimethylamine *N*-oxide, $\text{C}_3\text{H}_9\text{NO}$.

Healthy humans have a concentration of $3.90 \times 10^{-6} \text{ mol dm}^{-3}$ trimethylamine *N*-oxide in their blood.

An average adult human has 5.00 dm^3 of blood.

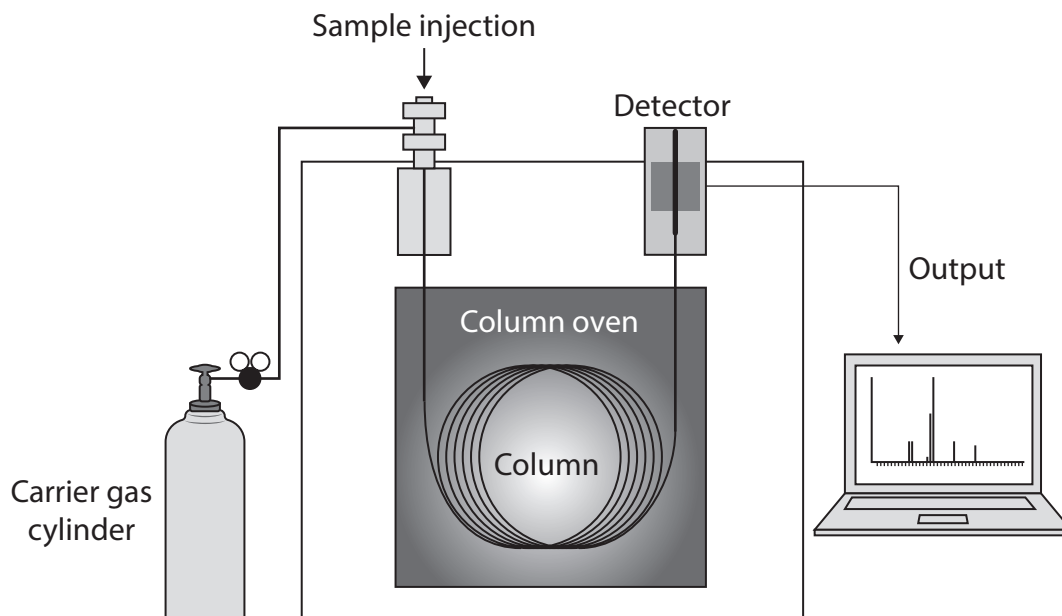
Calculate the mass, in grams, of trimethylamine *N*-oxide in an average human's blood, giving your answer to a suitable number of significant figures.

(2)



- (c) Trimethylamine is a major air pollutant originating from food waste, farm animals and vehicle exhausts. Trimethylamine levels need to be monitored as it can easily be absorbed through human skin.

Gas chromatography (GC) can be used to measure the level of trimethylamine in air, using the apparatus shown in the diagram.



- (i) Briefly describe how trimethylamine will be **separated** from other chemicals present in the sample of air.

(2)

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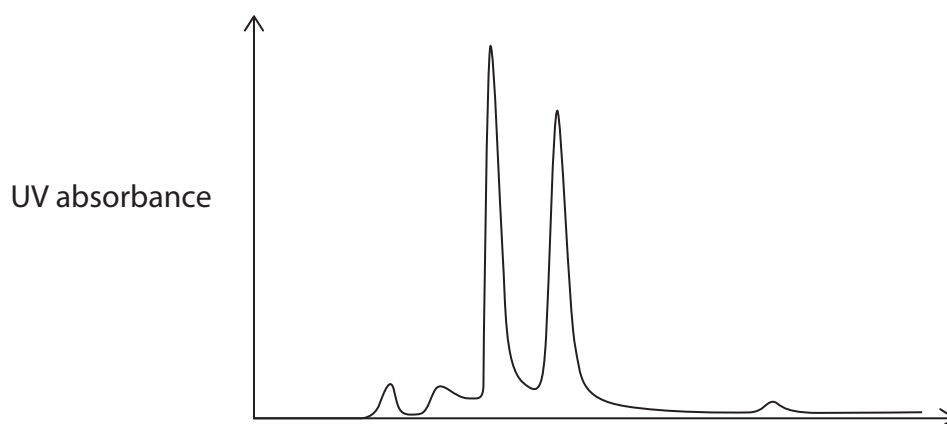
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- (ii) High-performance liquid chromatography (HPLC) is used to measure levels of trimethylamine and trimethylamine *N*-oxide in blood and urine.

Label the x-axis on the chromatogram.

(1)



- (iii) Name the analytical technique that can be used with either GC or HPLC to identify the compound responsible for each peak.

(1)

(Total for Question 17 = 11 marks)

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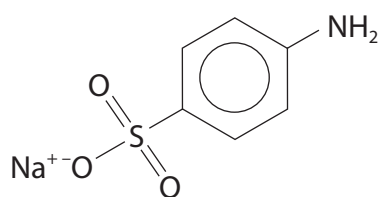
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18 Sunset yellow is a common food colouring.

Sunset yellow can be produced in a coupling reaction starting with compound **A**.



compound **A**

- (a) State the reagents and conditions required for the formation of a diazonium ion from compound **A**.

(2)

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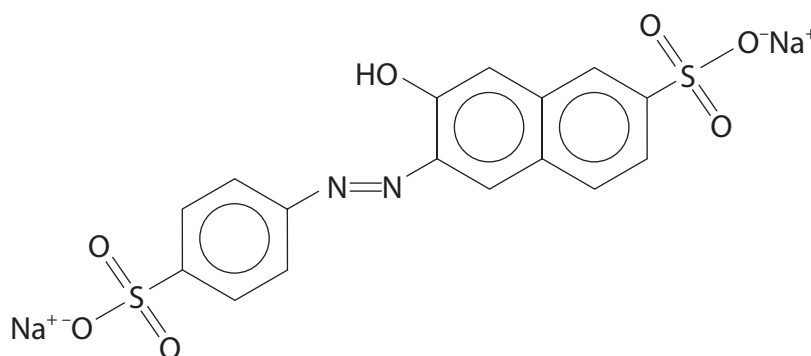
- (b) Draw the structure of the diazonium ion formed.

(1)

- (c) The structure of sunset yellow is shown.

Use a circle to identify the functional group, other than the diazonium group, that is essential for the coupling reaction to occur.

(1)



(d) (i) After sunset yellow is formed, it needs to be purified.

Name the process that is used.

(1)

(ii) The yield, by mass, for the formation of sunset yellow is 67.9%.

Calculate the mass of sunset yellow produced from 5.00 g of compound **A**.

[M_r of sunset yellow = 452.2]

(3)

(Total Question 18 = 8 marks)



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***19** A solution containing tetrachlorocuprate(II) ions, $[\text{CuCl}_4]^{2-}$, is treated with dilute aqueous ammonia.

The ammonia solution is added gradually.

The following observations are made:

yellow solution $\rightarrow$ pale blue solution $\rightarrow$ pale blue precipitate $\rightarrow$ deep blue solution

Explain the changes occurring in this sequence.

Your explanation should refer to the formulae, shapes and colours of the species present at each stage.

Detailed explanations of how the colours of transition metal complexes occur are not required.

(6)



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(Total for Question 19 = 6 marks)

TOTAL FOR SECTION B = 50 MARKS

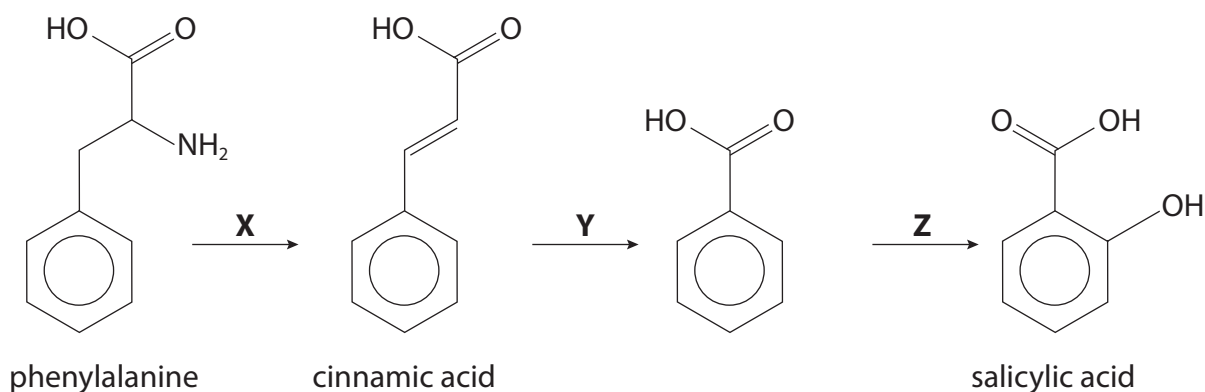


SECTION C

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

- 20** Salicylic acid has been characterised as a plant hormone and is often used by students to prepare aspirin.

Salicylic acid is produced in plants, from phenylalanine via cinnamic acid, using enzymes.



- (a) (i) Draw an asterisk (*) on the chiral carbon in phenylalanine.

(1)

- (ii) State the type of reaction taking place in Step X.

(1)

- (iii) Only one isomer of cinnamic acid is produced in Step X.

Draw the other geometric isomer of cinnamic acid.

(1)



- (iv) In Step **Y** a diol is formed as an intermediate before further oxidation. The mixture is heated so the reaction can proceed.

Suggest the reagents required to form the diol in the laboratory.

(2)

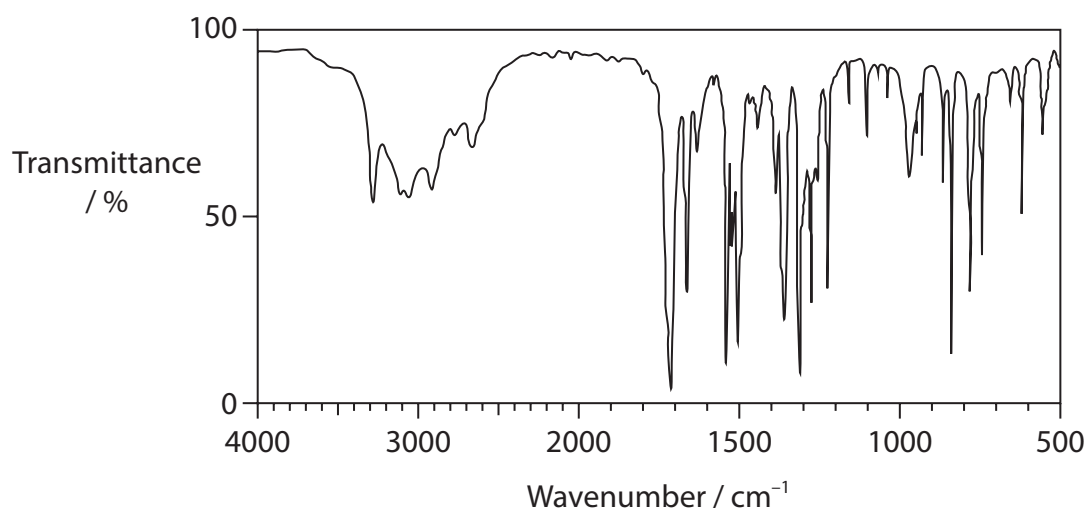
- (v) Suggest a reason why it is unlikely the reaction scheme proceeds by this route in plants.

(1)

- (b) State the IUPAC name for salicylic acid.

(1)

- (c) The infrared spectrum for salicylic acid is shown.



Identify **two** wavenumbers on the spectrum and the bond responsible for each which show that an aromatic group is present in salicylic acid.

Use your Data Booklet.

(2)

(d) 5-Nitrosalicylic acid, produced from salicylic acid, is an important raw material and intermediate used in organic synthesis.

- (i) Concentrated nitric and sulfuric acid are used to produce NO_2^+ to initiate the reaction.

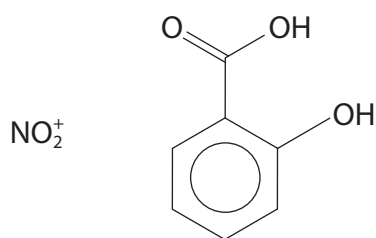
Write the equation for the production of NO_2^+ .

(1)

- (ii) Complete the reaction mechanism to form 5-nitrosalicylic acid, naming the reaction mechanism.

(5)

Reaction mechanism



(iii) Explain why benzenecarboxylic acid requires concentrated nitric and sulfuric acids for nitration while salicylic acid may be nitrated using dilute nitric acid.

(3)

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(e) 5-Nitrosalicylic acid has a solubility of 1 g in 1475 cm³ of water.

Calculate the concentration of a saturated solution in mol dm⁻³.

(2)

[5-nitrosalicylic acid $M_r = 183$]

(Total for Question 20 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 90 MARKS



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P 7 8 7 4 6 A 0 3 2 3 2

* Actinide series

140	Ce	cerium	58	141	Pr	praseodymium	59	144	Nd	neodymium	60	[147]	Pm	promethium	61	150	Sm	samarium	62	152	Eu	europium	63	157	Gd	gadolinium	64	159	Tb	terbium	65	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	238	U	uranium	92	231	Pa	protactinium	91	237	Np	neptunium	93	242	Pu	plutonium	94	243	Am	americium	95	247	Cm	curium	96	245	Bk	berkelium	97	251	Cf	californium	98	254	Es	einsteinium	99	253	Fm	fermium	100	256	Md	mendeleevium	101	254	No	nobelium	102	257	Lr	lawrencium	103

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