Pearson Edexcel International Advanced Level

Wednesday 14 January 2026

Morning (Time: 1 hour 45 minutes)

Paper reference **WCH15/01A**

Chemistry

International Advanced Level

UNIT 5: Transition Metals and Organic Nitrogen Chemistry
Question Paper

You must have:
Scientific calculator, Data Booklet, ruler and Answer Book (sent separately)

Turn over ▶

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P 8 7 6 2 8 A

Pearson

SECTION A

Answer ALL the questions in this section in the Answer Book.

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 in the box ☒ in the Answer Book. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 This question is about the reaction shown.

$$2Fe^{3+}(aq) + Ti(s) \rightarrow 2Fe^{2+}(aq) + Ti^{2+}(aq) \qquad E^{\ominus}_{cell} = +2.40V$$

(a) The electrode potential for the Fe^{3+}/ Fe^{2+} electrode system is +0.77V.

What is the electrode potential for the Ti^{2+}/ Ti electrode system?

(1)

A –3.17V

B –1.63V

C +1.63V

D +3.17V

(b) What metals should be used for the electrodes in the cell for this reaction?

(1)

	Metals used for the electrode	
	Fe^{3+}/ Fe^{2+} electrode system	Ti^{2+}/ Ti electrode system
A	iron	titanium
B	iron	platinum
C	platinum	titanium
D	platinum	platinum

(c) The half-cell for the Fe^{3+}/ Fe^{2+} electrode system is prepared by mixing **equal** volumes of solutions of iron(II) sulfate, $FeSO_4$, and iron(III) sulfate, $Fe_2(SO_4)_3$.

What concentrations of the **original** solutions are needed for the resulting mixture to be standard?

(1)

	Concentration of the original solution	
	$FeSO_4$	$Fe_2(SO_4)_3$
A	1 mol dm^{-3}	0.5 mol dm^{-3}
B	1 mol dm^{-3}	1 mol dm^{-3}
C	2 mol dm^{-3}	1 mol dm^{-3}
D	2 mol dm^{-3}	2 mol dm^{-3}

(Total for Question 1 = 3 marks)

2 Methanol can be used as the fuel in a fuel cell.

The half-equations for the reactions taking place in acidic conditions are

$$CO_2 + 6H^+ + 6e^- \rightleftharpoons CH_3OH + H_2O$$

$$\tfrac{1}{2}O_2 + 2H^+ + 2e^- \rightleftharpoons H_2O$$

The half-equations for the reactions taking place in alkaline conditions are

$$CO_2 + 5H_2O + 6e^- \rightleftharpoons CH_3OH + 6OH^-$$

$$\tfrac{1}{2}O_2 + H_2O + 2e^- \rightleftharpoons 2OH^-$$

The value for $E^{\ominus}_{cell}$ in alkaline conditions is exactly the same as $E^{\ominus}_{cell}$ in acidic conditions because the

A acid and alkali are catalysts

B $E^{\ominus}$ values for the half-equations are the same

C overall reaction is the same

D temperature and pressure are the same

(Total for Question 2 = 1 mark)

3 An electrochemical cell is set up to measure $E^{\ominus}_{cell}$ for the reaction

$$Fe(s) + Sn^{2+}(aq) \rightarrow Fe^{2+}(aq) + Sn(s)$$

What is the cell diagram for this cell using the conventional representation of half-cells?

A $Fe(s) \mid Fe^{2+}(aq) \parallel Sn(s) \mid Sn^{2+}(aq)$

B $Fe^{2+}(aq) \mid Fe(s) \parallel Sn^{2+}(aq) \mid Sn(s)$

C $Fe(s) \mid Fe^{2+}(aq) \parallel Sn^{2+}(aq) \mid Sn(s)$

D $Fe^{2+}(aq) \mid Fe(s) \parallel Sn(s) \mid Sn^{2+}(aq)$

(Total for Question 3 = 1 mark)

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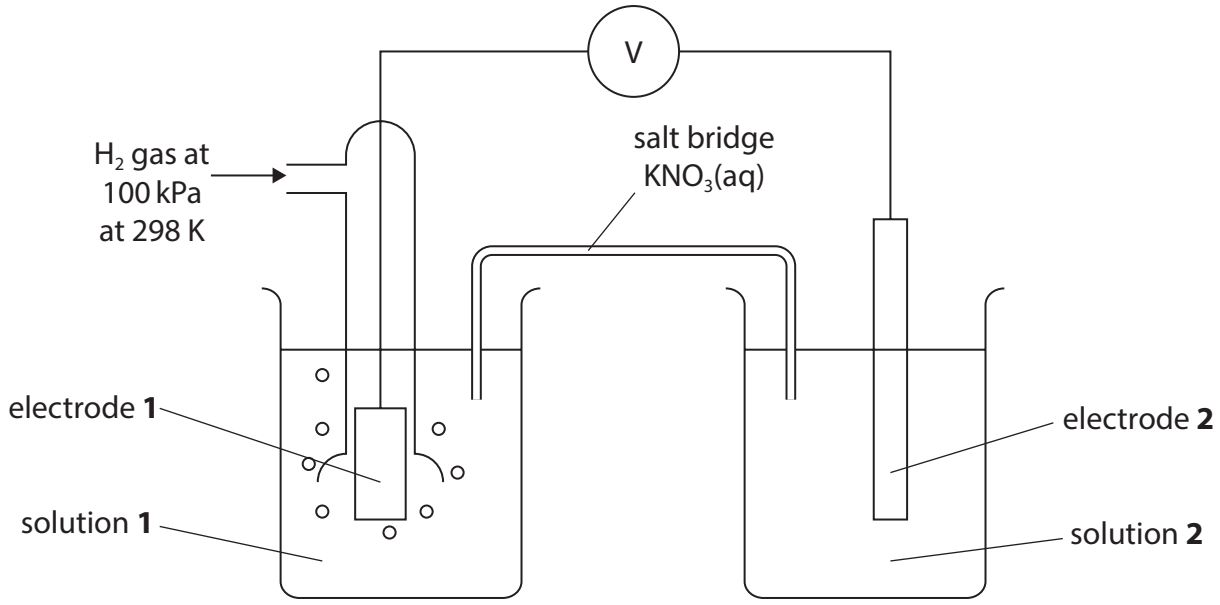
4 The apparatus shown was used to measure the standard electrode potential for the reduction of $Cr_2O_7^{2-}$ ions to Cr^{3+} ions in acid solution.

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightarrow 2Cr^{3+}(aq) + 7H_2O(l)$$



(a) Solution **2** is **best** acidified with

(1)

A H_2SO_4

B HCl

C HBr

D H_2CrO_4

(b) Solution **2** contains 14.71 g of $K_2Cr_2O_7$.

What mass of $Cr_2(SO_4)_3 \cdot 18H_2O$ should also be used?

[Data: M_r $K_2Cr_2O_7 = 294.2$ $Cr_2(SO_4)_3 = 392.3$ $Cr_2(SO_4)_3 \cdot 18H_2O = 716.3$]

(1)

A 9.81 g

B 17.91 g

C 19.62 g

D 35.82 g

(Total for Question 4 = 2 marks)

5 Which of the following elements is both a d-block element and a transition element?

A calcium

B copper

C scandium

D zinc

(Total for Question 5 = 1 mark)

6 A ligand exchange reaction occurs when EDTA is added to a solution containing the ion $[Cu(H_2O)_2(NH_3)_4]^{2+}$.

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

A a complex forms with copper and EDTA which is more soluble than the original

B a complex forms with copper and EDTA which is less soluble than the original

C $\Delta H_{reaction}$ is positive for the reaction of $[Cu(H_2O)_2(NH_3)_4]^{2+}$ with EDTA

D ΔS_{system} is positive for the reaction of $[Cu(H_2O)_2(NH_3)_4]^{2+}$ with EDTA

(Total for Question 6 = 1 mark)

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

7 Zinc hydroxide reacts with acids to form $[Zn(H_2O)_6]^{2+}$ ions and with alkalis to form $[Zn(OH)_4]^{2-}$ ions.

From this information, it can be deduced that zinc hydroxide is

A only acidic

B only basic

C amphoteric

D not acidic, basic or amphoteric

(Total for Question 7 = 1 mark)

8 Which are the correct colours of the complex ions formed by copper(II) ions with butylamine and with chloride ions?

	$[Cu(C_4H_9NH_2)_4(H_2O)_2]^{2+}$	$[CuCl_4]^{2-}$
A	blue	green
B	blue	yellow
C	yellow	blue
D	yellow	green

(Total for Question 8 = 1 mark)

9 Platinum forms a complex with the formula $Pt(NH_3)_2Cl_2$ and chromium forms a complex with the formula $CrCl_4^-$.

What are the shapes of these complexes?

(1)

A both complexes are square planar

B both complexes are tetrahedral

C $Pt(NH_3)_2Cl_2$ is tetrahedral and $CrCl_4^-$ is square planar

D $Pt(NH_3)_2Cl_2$ is square planar and $CrCl_4^-$ is tetrahedral

(Total for Question 9 = 1 mark)

10 A sample of 0.25 mol of a cyclic hydrocarbon produced 66 g of carbon dioxide and 22.5 g of water on combustion. The hydrocarbon is

A cyclohexane

B cyclohexene

C benzene

D ethylbenzene

(Total for Question 10 = 1 mark)

11 Grignard reagents react with

A water giving primary alcohols

B all aldehydes giving secondary alcohols

C ketones giving secondary or tertiary alcohols

D carbon dioxide giving carboxylic acids

(Total for Question 11 = 1 mark)

12 When recrystallisation is used to purify a solid, which of the following statements is true?

A all insoluble impurities are removed by filtering the hot solution

B all soluble impurities are removed by filtering the hot solution

C all impurities must be insoluble in the solvent used

D all impurities must be soluble in the solvent used

(Total for Question 12 = 1 mark)

13 The reaction of ethene with bromine occurs under normal laboratory conditions, but the reaction of benzene with bromine to form bromobenzene requires heat and the presence of a catalyst.

The best explanation for the difference in reactivity is that the delocalised electrons in benzene

A result in a kinetic barrier to intermediate formation

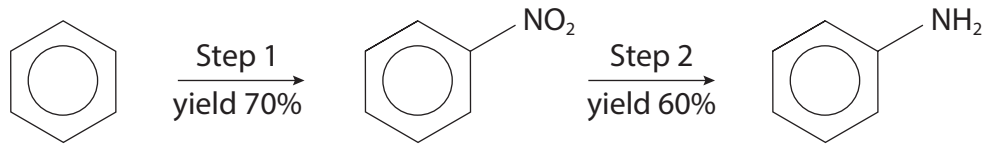
B repel electrophiles

C result in benzene having an endothermic enthalpy of formation

D make benzene thermodynamically stable with respect to the formation of bromobenzene

(Total for Question 13 = 1 mark)

14 Phenylamine can be produced from benzene by the reaction sequence shown.



benzene
$M_r = 78$

phenylamine
$M_r = 93$

The mass of phenylamine, to 2 decimal places, produced from 3.90 g of benzene is

A 1.95 g

B 2.79 g

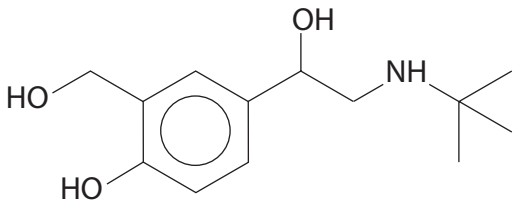
C 3.26 g

D 4.65 g

(Total for Question 14 = 1 mark)

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

15 The structure of the asthma medication salbutamol is shown.



(a) Which functional group is **not** present in salbutamol?

(1)

A alcohol

B amide

C amine

D phenol

(b) What is the molecular formula of salbutamol?

(1)

A $C_{13}H_{22}NO_3$

B $C_{13}H_{21}NO_3$

C $C_{13}H_{20}NO_3$

D $C_{13}H_{19}NO_3$

(Total for Question 15 = 2 marks)

16 Separate 0.1 mol dm^{-3} aqueous solutions of ammonia, butylamine and phenylamine were prepared.

Which of the following sequences shows the solutions in order of **increasing** pH?

A phenylamine, ammonia, butylamine

B ammonia, butylamine, phenylamine

C butylamine, phenylamine, ammonia

D ammonia, phenylamine, butylamine

(Total for Question 16 = 1 mark)

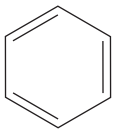
TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions in the Answer Book.

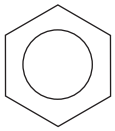
17 This question is about benzene and some of its compounds.

(a) In 1865, Kekulé suggested that the benzene molecule was a six-membered carbon ring with alternate double and single bonds.



However, this suggestion does not fully explain the structure and stability of benzene.

Explain evidence from **three** distinct methods that led to this structure of benzene being rejected, in favour of benzene with a ring of delocalised electrons.



(3)

(b) Benzene reacts with a mixture of concentrated nitric acid and concentrated sulfuric acid to form nitrobenzene.

Draw the mechanism for this reaction, **including** the formation of the electrophile.

(4)

(c) Benzene reacts with pure bromine in the presence of a Friedel-Crafts catalyst. Phenol reacts with bromine water at room temperature.

(i) Write the equation for the reaction between phenol and **excess** bromine water.

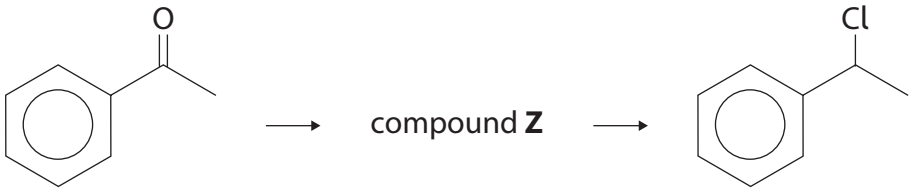
State symbols are not required.

(2)

(ii) Explain why phenol reacts with bromine under much milder conditions than those required for the reaction between benzene and bromine.

(2)

(d) (1-Chloroethyl)benzene is used in perfumes and can be produced in two steps from 1-phenylethan-1-one.



1-phenylethan-1-one (1-chloroethyl)benzene

Draw the structure of compound **Z**.

(1)

(e) N-phenylethanamide can be produced from nitrobenzene in a two-step process.

State the reagents and reaction conditions for each step.

(2)

(Total for Question 17 = 14 marks)

18 (a) Steel is an alloy of iron and carbon. A group of students determined the iron content of a sample of steel wire by a redox titration method.

The relevant half-equations are shown.

$$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$$

$$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$$

A known mass of the wire was dissolved in dilute sulfuric acid and the resulting solution made up to 250.0 cm^3 with more dilute sulfuric acid and mixed thoroughly.

$$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$$

25.0 cm^3 samples of the resulting solution were titrated with 0.0195 mol dm^{-3} potassium manganate(VII) solution.

(i) State the colour **change** at the end-point of the titration.

(1)

(ii) One student used 2.06 g of the wire (weighed directly on the balance pan) and obtained a mean titre of 29.15 cm^3.

Calculate the percentage of iron in the steel wire. Give your answer to **three** significant figures.

(5)

(iii) A second student carried out the same experiment but incorrectly used deionised water instead of sulfuric acid to make up the solution in the volumetric flask.

The student observed a brown suspension forming during the titration.

Explain how, if at all, the titre value would be affected by the student error.

Use the table of data in the Answer Book when you answer this question.

(3)

(b) The uncertainties of the apparatus used in the experiment are shown.

Apparatus	Value measured	Uncertainty on each reading	Percentage uncertainty on value measured / %
Balance	2.06 g	±0.005 g	0.49
Burette	29.15 cm^3	±0.05 cm^3	
Pipette	25.0 cm^3	±0.06 cm^3	
Volumetric flask	250.0 cm^3	±0.3 cm^3	

Complete the table in the Answer Book.

(2)

(Total for Question 18 = 11 marks)

19 This question is about the element chromium and some of its compounds.

(a) (i) Complete the electronic configuration in the Answer Book of the chromium atom, using the s, p, d notation.

(1)

(ii) The electronic configuration of the chromium atom is unusual compared with that of most other transition metals.

Give **two** reasons why chromium atom has this electronic configuration.

(2)

(b) (i) A solution containing chromium(II) ions can be produced in the laboratory by reducing a solution of potassium dichromate(VI) using 50% hydrochloric acid and zinc. This reaction takes place in two steps.
First the dichromate(VI) ions are reduced to chromium(III) ions.
Then the chromium(III) ions are reduced to chromium(II) ions.

Calculate the $E^{\ominus}_{cell}$ values for each step, stating why these are spontaneous.

Use your Data Booklet.

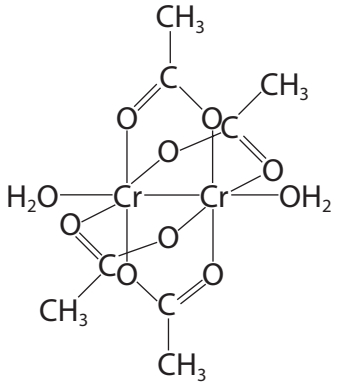
(3)

(ii) State the colour changes you would expect to see during this reaction.

(1)

(c) Chromium(II) ions in aqueous solution are quickly oxidised by the oxygen in air. One method of stabilising chromium(II) ions is by adding a solution of sodium ethanoate, forming a complex, $[Cr_2(CH_3CO_2)_4(H_2O)_2]$.

This complex may be represented by the structure below.



(i) State the type of ligand that the ethanoate ion is in this complex.

(1)

(ii) Name the type of bonding between the ethanoate ligands and the chromium(II) ion.

(1)

(iii) Suggest **two** unusual features in the structure of this complex.

(2)

(iv) The resulting complex is red.
Explain why the colour of chromium(II) ethanoate complex is different from that of $[Cr(H_2O)_6]^{2+}$.

(2)

(d) Chromium(III) chloride can exist in aqueous solution as three possible complex ions with some free chloride ions.

	Complex ion	Free chloride ions
X	$[Cr(H_2O)_6]^{3+}$	$3Cl^-$
Y	$[CrCl(H_2O)_5]^{2+}$	$2Cl^-$
Z	$[CrCl_2(H_2O)_4]^{+}$	Cl^-

(i) There are two possible structures for complex ion **Z**.

Complete the diagrams in the Answer Book to show the two possible structures for complex ion **Z**.

(2)

(ii) The formula of the complex ion formed in the solution is found by adding aqueous silver nitrate to the solution. This reacts only with the free chloride ions to form a precipitate of silver chloride.

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

The precipitate is then filtered, washed, dried and weighed.

In an experiment, 0.024 mol of one of the forms of chromium(III) chloride was used and 6.88 g of silver chloride was formed.

Deduce the formula of the complex ion. You must show your working.

(3)

(Total for Question 19 = 18 marks)

***20** Rhodium is one of the metals used as a catalyst for the removal of pollutants from the exhaust fumes of car engines.

Vanadium(V) oxide is a catalyst used in the Contact Process for the manufacture of sulfuric acid.

Compare and contrast the mechanism of action of both of these catalysts.
Include relevant equations.

General definitions of catalysts are not required.

(6)

(Total for Question 20 = 6 marks)

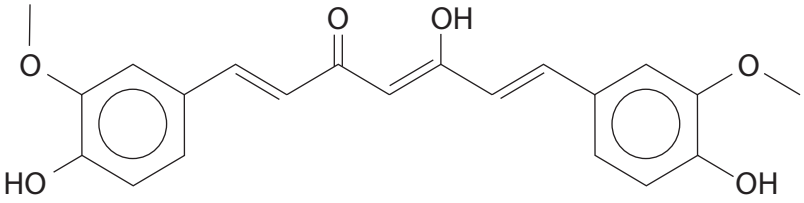
TOTAL FOR SECTION B = 49 MARKS

SECTION C

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

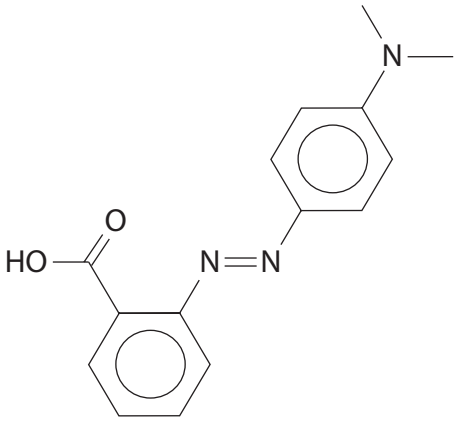
21 Organic molecules are an important source of colour in both the natural world and in a wide range of industrial applications.

The naturally occurring compound curcumin contributes to the yellow colour of turmeric spice. It is used as an additive in cosmetics and foods. Research also suggests that curcumin can act as an antioxidant and anticancer agent, through reaction with free radicals and proteins. Excitingly, it may also inhibit Alzheimer's disease by complexing to toxic metal ions.



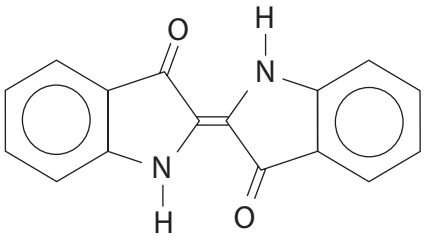
curcumin

Azo dyes are synthetic compounds that do not occur naturally. They can be used to colour textiles such as cotton. The acid-base indicator methyl red is an azo dye.

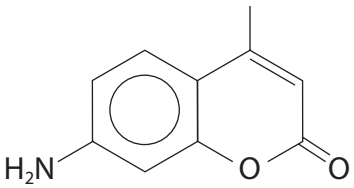


methyl red

Indigotin is used to dye denim a blue colour and coumarin 440 is used to generate blue light in lasers. Both dyes occur naturally in plants but can be synthesised in the laboratory.

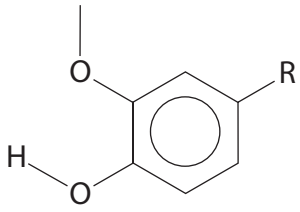


indigotin



coumarin 440

A simplified structure of curcumin is shown.



(a) Complete the left-hand side of the equation in the Answer Book by adding curly half-arrows.

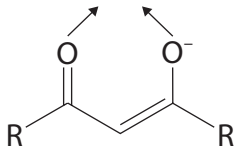
(1)

(b) Selenide anions attached to protein side-chains may undergo nucleophilic addition reactions with curcumin.

Complete the mechanism in the Answer Book for one of the steps in such a reaction, adding curly arrows to the simplified structures shown.

(2)

(c) Curcumin anions can act as bidentate ligands in metal-curcumin (M-curc) complexes. The oxygen atoms of the curc ligand occupy adjacent coordination sites in the complex as shown.

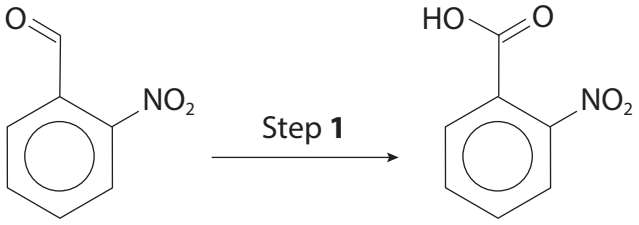


The formulae of two complexes formed with the curc ligand are $[Co(curc)_2]^+$ and $Fe(curc)(C_2H_5OH)_2(NO_3)_2$.
State the coordination number and shape for each complex.

(2)

(d) Methyl red can be synthesised starting from 2-nitrobenzaldehyde and phenylamine.

(i) State the reagents and conditions needed in Step **1**.



2-nitrobenzaldehyde 2-nitrobenzoic acid

(2)

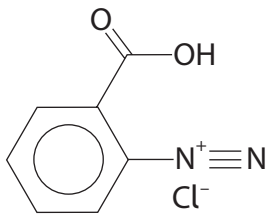
(ii) Write the equation for the reduction of 2-nitrobenzoic acid to produce 2-aminobenzoic acid.

Use [H] to represent the reducing agent.

(2)

(iii) 2-Aminobenzoic acid is then converted to the 2-carboxybenzenediazonium ion shown.

(1)

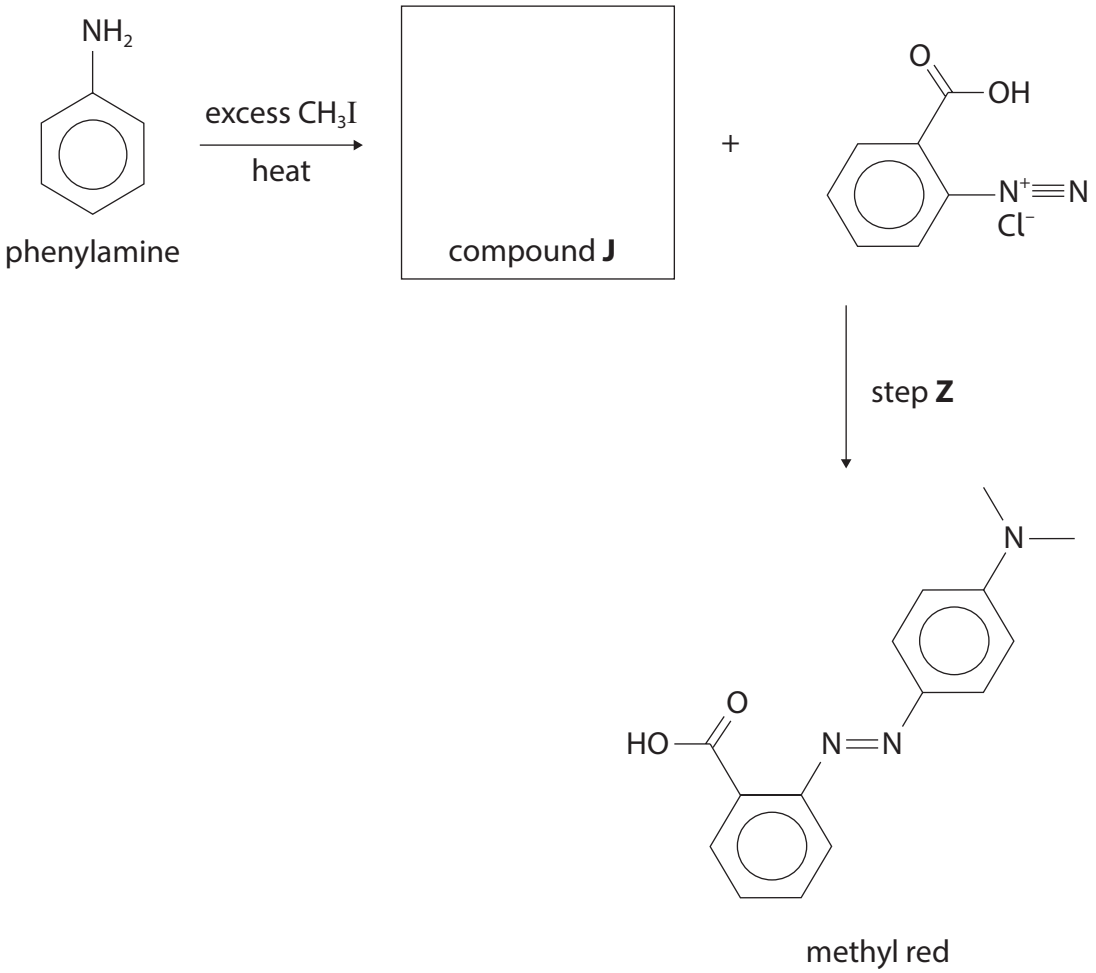


State the reagents needed for this conversion.

(iv) The final steps of the synthesis of methyl red are shown in the diagram below.

Give the structure of compound **J** in the labelled box in the Answer Book.

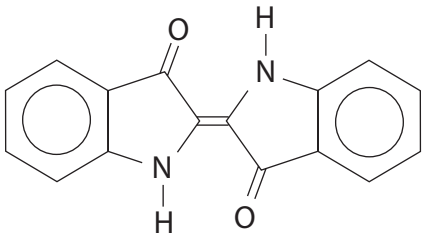
(1)



(v) The temperature used in Step **Z** should be kept as close to 5 °C as possible. Suggest why the temperature should be kept this low.

(1)

(e) Indigotin can be synthesised from 2-nitrobenzaldehyde and propanone in aqueous sodium hydroxide.



indigotin

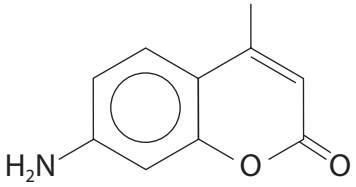
(i) Complete the equation for this reaction in the Answer Book.

(2)

(ii) Calculate the mass of 2-nitrobenzaldehyde required to make 5.00 g of indigotin from this reaction when the percentage yield is 83.5%.

(4)

(f) Give the structure of the **organic** product of each of the following reactions of coumarin 440.



coumarin 440

(i) Hydrolysis with **excess** aqueous sodium hydroxide.

(2)

(ii) Condensation with ethanoyl chloride.

(1)

(Total for Question 21 = 21 marks)

TOTAL FOR SECTION C = 21 MARKS
TOTAL FOR PAPER = 90 MARKS

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Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Wednesday 14 January 2026

Morning (Time: 1 hour 45 minutes)

Paper reference **WCH15/01A**

▲ △

Chemistry

International Advanced Level

UNIT 5: Transition Metals and Organic Nitrogen Chemistry

Answer Book

You must have:
Question paper (sent separately)
Scientific calculator, 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 questions 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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C:1/1/1/1/1/

P 8 7 6 2 7 A 0 1 2 8

Pearson

SECTION A

Answer ALL questions.

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

For questions 1–10, in Section A, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1

(a)

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(b)

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(c)

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 1 = 3 marks)

2

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 2 = 1 mark)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

3

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 3 = 1 mark)

4

(a)

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(b)

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 4 = 2 marks)

5

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 5 = 1 mark)

6

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 6 = 1 mark)

7

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 7 = 1 mark)

8

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 8 = 1 mark)

9

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 9 = 1 mark)

10

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 10 = 1 mark)

11

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 11 = 1 mark)

12

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 12 = 1 mark)

13

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 13 = 1 mark)

14

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 14 = 1 mark)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

15 (a)

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(b)

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 15 = 2 marks)

16

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 16 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

SECTION B

Answer ALL questions in the spaces provided.

17

(a)

(3)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(b)

(4)

(c)

(i)

(2)

(ii)

(2)

(d)

(1)

(e)

(2)

Step **1**

.....

Step **2**

.....

(Total for Question 17 = 14 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

18 (a)

(i)

(1)

.....

(ii)

(5)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(iii)

(3)

	Electrode reaction	$E^{\ominus}$ / V
1	$MnO_4^- + e^- \rightleftharpoons MnO_4^{2-}$	+0.56
2	$MnO_4^- + 2H_2O + 2e^- \rightleftharpoons MnO_2 + 4OH^-$	+0.59
3	$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	+0.77
4	$MnO_2 + 4H^+ + 2e^- \rightleftharpoons Mn^{2+} + 2H_2O$	+1.23
5	$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$	+1.51
6	$MnO_4^- + 4H^+ + 3e^- \rightleftharpoons MnO_2 + 2H_2O$	+1.70
7	$MnO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons MnO_2 + 2H_2O$	+2.26

(b)

(2)

Apparatus	Value measured	Uncertainty on each reading	Percentage uncertainty on value measured / %
			0.49

(Total for Question 18 = 11 marks)

19

(a) (i)

(1)

Cr [Ar] .....

(ii)

(2)

.....

.....

.....

.....

.....

.....

(b) (i)

(3)

.....

(ii)

(1)

.....

.....

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(c)

(i)

(1)

(ii)

(1)

(iii)

(2)

(iv)

(2)

DO NOT WRITE IN THIS AREA

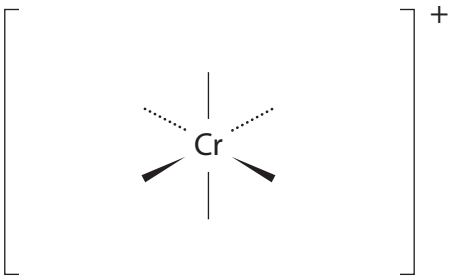
DO NOT WRITE IN THIS AREA

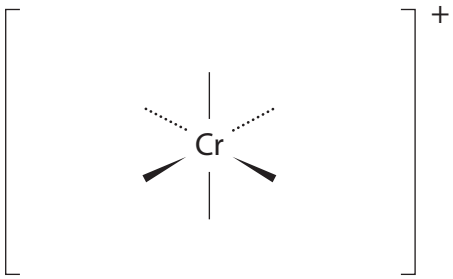
DO NOT WRITE IN THIS AREA

(d)

(i)

(2)





(ii)

(3)

(Total for Question 19 = 18 marks)

***20**

(6)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 20 = 6 marks)

TOTAL FOR SECTION B = 49 MARKS

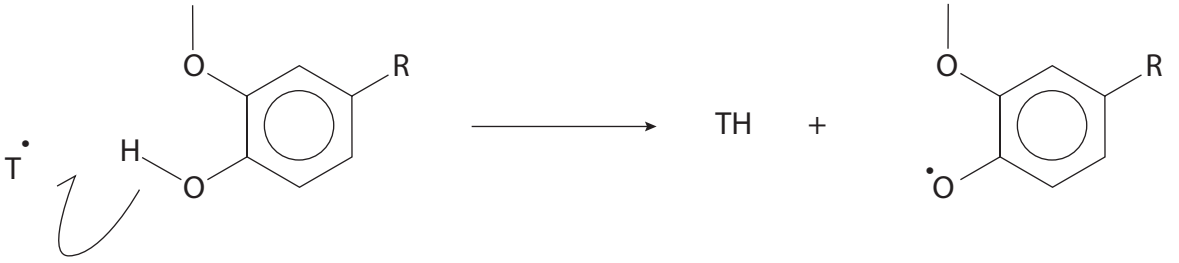
SECTION C

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

21

(a)

(1)



(b)

(2)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(c)

(2)

(d) (i)

(2)

(ii)

(2)

(iii)

(1)

.....

(iv)

compound **J**

(1)

(v)

(1)

.....

.....

.....

DO NOT WRITE IN THIS AREA

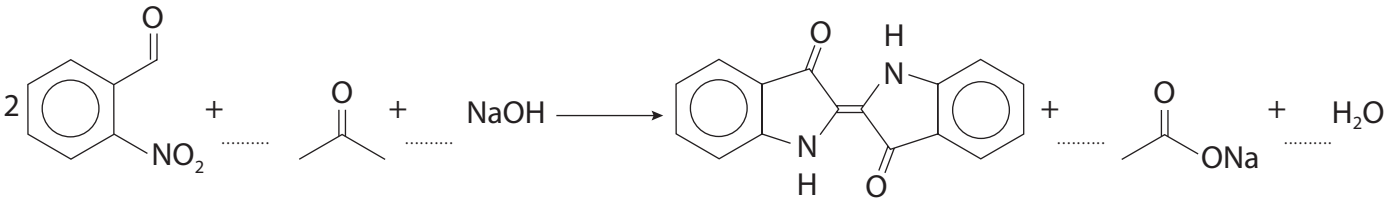
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(e)

(i)

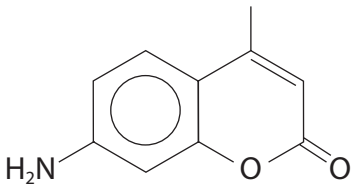
(2)



(ii)

(4)

(f)



coumarin 440

(i)

(2)

(ii)

(1)

(Total for Question 21 = 21 marks)

TOTAL FOR SECTION C = 21 MARKS
TOTAL FOR PAPER = 90 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
																	(18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)											(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											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	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	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	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	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	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	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							

Key: relative atomic mass / **atomic symbol** / name / atomic (proton) number

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide 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
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[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 mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103