



Rewarding Learning

ADVANCED
General Certificate of Education
2023

Centre Number

--	--	--	--	--

Candidate Number

--	--	--	--	--

Chemistry

StemUp Model Solution

Assessment Unit A2 2

assessing

Analytical, Transition Metals,
Electrochemistry and Further
Organic Chemistry



[ACH24]

ACH24

MONDAY 12 JUNE, MORNING

TIME

2 hours.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

Answer **all fifteen** questions in **Sections A and B**.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen or a pencil.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 110.

Quality of written communication will be assessed in Questions **13(c)** and **14(f)(iii)**.

The figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements, containing some data, is included with this question paper.

13622.06R

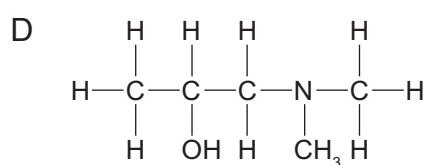
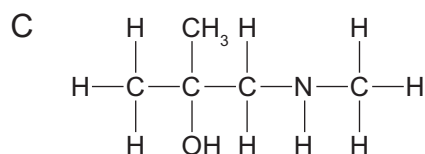
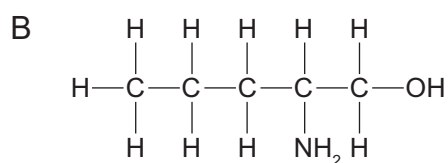
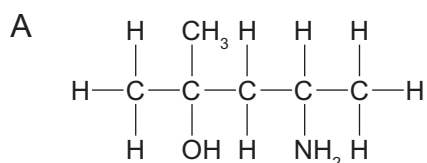


Section A

For each of the following questions, only **one** of the lettered responses (A–D) is correct.

Select the correct response for each question and write the appropriate letter in the space provided.

1 Which one of the following compounds is a tertiary alcohol and a secondary amine?



Answer C [1]



- 2 Which one of the following does **not** give the correct colour change when the reaction occurs in solution?

	Reaction	Colour change
A	Excess KI(aq) added to acidified $\text{KIO}_3(\text{aq})$	colourless to brown
B	Excess $\text{FeSO}_4(\text{aq})$ added to acidified $\text{KMnO}_4(\text{aq})$	colourless to pink
C	Excess $\text{NH}_3(\text{aq})$ added to $\text{CuSO}_4(\text{aq})$	blue to deep blue
D	Excess $\text{HCl}(\text{aq})$ added to $\text{NaOH}(\text{aq})$ containing methyl orange	yellow to red

Answer B [1]

- 3 Which one of the following shows the correct formula of the compound and one of its uses?

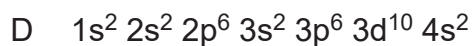
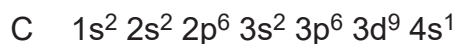
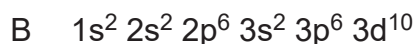
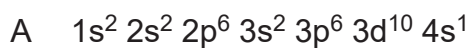
	Compound	Formula	Use
A	calcium carbonate	CaCO_3	painkiller
B	cisplatin	$[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]^{2+}$	cancer treatment
C	salicylic acid	$\text{C}_7\text{H}_6\text{O}_3$	wart treatment
D	silver nitrate	AgNO_3	antacid

Answer C [1]

[Turn over



4 Which one of the following is the electronic configuration of a copper(I) ion?



Answer B [1]

5 Which one of the following can only act as a monodentate ligand?

A 1,2-diaminoethane

B ethanedioate ions

C edta

D hydroxide ions

Answer D [1]

6 Which one of the following shows only two singlets on its high resolution ^1H nmr spectrum?

A ethane

B methyl ethanoate

C propanone

D pentan-2-one

Answer B [1]



- 7 Which one of the following is the correct IUPAC name and molecular formula for the organic compound formed when butylamine reacts with propanoyl chloride?

IUPAC name	Molecular formula
A N-butylpropanamide	$C_7H_{15}NO$
B N-butylpropanamide	$C_7H_{17}NO_2$
C N-propylbutanamide	$C_7H_{15}NO$
D N-propylbutanamide	$C_7H_{17}NO_2$

Answer A [1]

- 8 Which one of the following is the volume of $0.0525 \text{ mol dm}^{-3}$ potassium manganate(VII) solution required to react with 25.0 cm^3 of $0.105 \text{ mol dm}^{-3}$ iron(II) sulfate solution made up in sulfuric acid?

- A 2 cm^3
B 10 cm^3
C 50 cm^3
D 250 cm^3

Answer B [1]

- 9 Which one of the following compounds is the strongest base?

- A $(CH_3CH_2)_2NH$
B CH_3CONH_2
C $CH_3CH_2NH_2$
D $C_6H_5NH_2$

Answer A [1]

[Turn over]

13622.06R



10 Which one of the following is the formula of copper(II) arsenate(V)?

- A CuAsO_4
- B Cu_2AsO_4
- C $\text{Cu}(\text{AsO}_4)_2$
- D $\text{Cu}_3(\text{AsO}_4)_2$

Answer D [1]





BLANK PAGE

DO NOT WRITE ON THIS PAGE

(Questions continue overleaf)

13622.06R

[Turn over

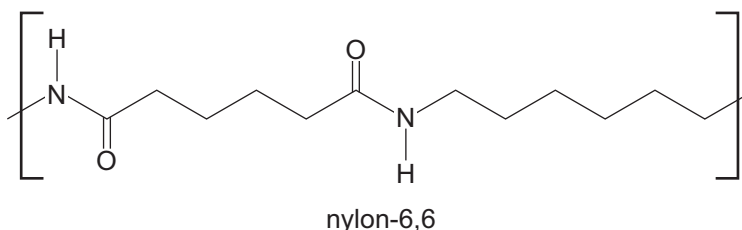


Section B

Answer **all five** questions in the spaces provided.

11 Small molecules which combine to form a polymer are called monomers.

(a) The repeating unit of a polymer called nylon-6,6 is shown below.



(i) State the IUPAC names of two monomers used to form this polymer.

hexane-1,6-diamine

hexanedioic acid

[2]

(ii) State two different terms which may be used to describe the type of polymer shown.

condensation polymer

polyamide

[2]

(iii) Explain why the polymer is referred to as nylon-**6,6**.

Each of the two monomers (the diamine and the dicarboxylic acid) contains 6 carbon atoms.

[1]

(iv) A section of nylon-6,6 contains 240 of the repeating unit shown above. Calculate the relative formula mass of this section of polymer.

M_r of repeating unit $C_{12}H_{22}N_2O_2 = 226$

$226 \times 240 = 54\,240$

Answer 54 240

[1]



- (v) Nylon is a biodegradable polymer. Define the term **biodegradable** and explain why nylon is biodegradable.

A biodegradable polymer can be broken down (hydrolysed) by the action of micro-organisms in the environment.

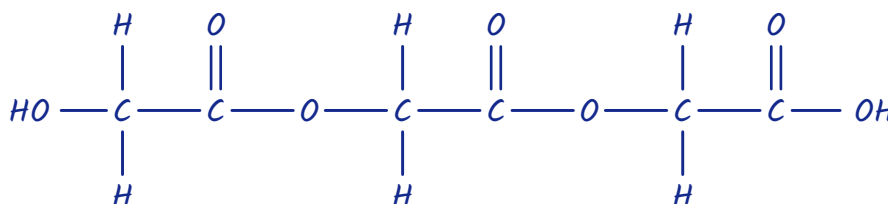
Nylon contains amide groups, which can be hydrolysed. [2]

- (vi) Explain why nylon-6,6 melts at a higher temperature than a polymer such as polythene.

Nylon chains have hydrogen bonds (permanent dipole-dipole attractions) between them, which are stronger than the van der Waals forces between polythene molecules. [2]

- (b) Hydroxyethanoic acid can form a polymer.

- (i) Draw the structural formula of the organic molecule formed from the polymerisation of three hydroxyethanoic acid molecules in acidic conditions.



[2]

- (ii) Name the functional group formed when hydroxyethanoic acid undergoes polymerisation.

ester [1]

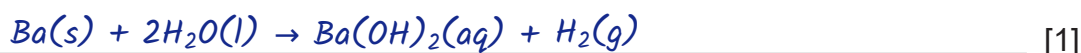
[Turn over]



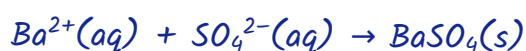
12 Many inorganic reactions involve the production of a gas or the formation of a precipitate.

(a) A series of reactions occurs when a piece of solid barium is added to a solution containing copper(II) sulfate. Bubbles of hydrogen gas are formed in the solution. A white precipitate and a blue precipitate are both produced.

(i) Write an equation for barium reacting with water in the solution.



(ii) Write ionic equations for the reactions which occur to produce both precipitates. Identify the white precipitate and the blue precipitate.



The white precipitate is barium sulfate, BaSO_4 .



The blue precipitate is copper(II) hydroxide, Cu(OH)_2 .

[4]



(b) The following tests were carried out on solutions labelled **A**, **B** and **C** and the results recorded in the table.

Solution	A	B	C
Test			
Add silver nitrate solution	white precipitate	yellow precipitate	no change
Add hydrochloric acid	no effervescence	no effervescence	effervescence
Add ammonia solution	green precipitate which dissolved in excess ammonia solution to form a blue solution	blue precipitate which dissolved in excess ammonia solution to form a yellow solution	no observable change

(i) Write the formulae for the following which are highlighted in bold in the table.

White precipitate AgCl

Gas which causes effervescence CO_2

Green precipitate $\text{Ni}(\text{OH})_2$

Yellow solution $[\text{Co}(\text{NH}_3)_6]^{2+}$ [4]

(ii) Identify **A** and **B**.

A nickel(II) chloride, NiCl_2

B cobalt(II) iodide, CoI_2 [2]

(iii) **C** cannot be fully identified from the tests carried out. Suggest one possible identity for **C** and describe another test which could be carried out to identify it more fully.

C could be sodium carbonate, Na_2CO_3 .

Carry out a flame test: a yellow-orange flame shows sodium ions are present. [2]

[Turn over



13 Some standard electrode potentials are given below.

Half-equation for standard electrode potential	$E^\ominus / \text{V}$
$\text{V}^{3+}(\text{aq}) + \text{e}^- \rightleftharpoons \text{V}^{2+}(\text{aq})$	-0.26
$\text{SO}_4^{2-}(\text{aq}) + 4\text{H}^+(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{SO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$	+0.17
$\text{VO}^{2+}(\text{aq}) + 2\text{H}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{V}^{3+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$	+0.32
$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Cu}(\text{s})$	+0.34
$\text{I}_2(\text{aq}) + 2\text{e}^- \rightleftharpoons 2\text{I}^-(\text{aq})$	+0.54
$\text{VO}_2^+(\text{aq}) + 2\text{H}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{VO}^{2+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$	+1.00
$\text{Cl}_2(\text{g}) + 2\text{e}^- \rightleftharpoons 2\text{Cl}^-(\text{aq})$	+1.36

(a) VO_2^+ in acidic solution can be reduced to VO^{2+} by iodide ions.

(i) Write an ionic equation for the reaction.



[2]

(ii) Calculate the emf for the reaction in (a)(i).

$$\text{emf} = +1.00 - (+0.54)$$

Answer +0.46 V [1]



- (b) A solution containing 131 mg of $(\text{VO}_2)_2\text{SO}_4$ is acidified using an excess of sulfuric acid and mixed with a solution containing 441 mg of VSO_4 . The following reaction occurs.



- (i) Complete the table, giving the colour of the vanadium compounds in solution.

Vanadium compound	Colour
$(\text{VO}_2)_2\text{SO}_4(\text{aq})$	<i>yellow</i>
$\text{VSO}_4(\text{aq})$	<i>violet</i>
$\text{V}_2(\text{SO}_4)_3(\text{aq})$	<i>green</i>

[3]

- (ii) Calculate the mass, in mg, of $\text{V}_2(\text{SO}_4)_3$ which will be present in the solution when the reaction is complete.

$$\text{moles } (\text{VO}_2)_2\text{SO}_4 = 0.131 \div 262 = 5.00 \times 10^{-4} \text{ mol}$$

$$\text{moles } \text{VSO}_4 = 0.441 \div 147 = 3.00 \times 10^{-3} \text{ mol}$$

$$4 \times 5.00 \times 10^{-4} = 2.00 \times 10^{-3} \text{ mol } \text{VSO}_4 \text{ needed,}$$

so $(\text{VO}_2)_2\text{SO}_4$ is the limiting reactant

$$\text{moles } \text{V}_2(\text{SO}_4)_3 = 3 \times 5.00 \times 10^{-4} = 1.50 \times 10^{-3} \text{ mol}$$

$$\text{mass} = 1.50 \times 10^{-3} \times 390 = 0.585 \text{ g} = 585 \text{ mg}$$

Answer 585 mg [4]

- (iii) Identify an oxidising agent from the table of standard electrode potentials which would oxidise vanadium from the +2 to the +4 oxidation state but not to the +5 oxidation state.

iodine, I_2 [1]

[Turn over]



- (c) Describe how the standard electrode potential of the Cu^{2+}/Cu half-cell could be measured using a standard hydrogen electrode. State the conditions needed.

In this question you will be assessed on your written communication skills including the use of specialist scientific terms.

Set up a standard hydrogen electrode: hydrogen gas at 100 kPa is bubbled over a platinum electrode dipping into a solution containing 1 mol dm⁻³ H⁺ ions (e.g. HCl).

Set up the Cu^{2+}/Cu half-cell by dipping a copper electrode into a solution containing 1 mol dm⁻³ Cu^{2+} ions (e.g. copper(II) sulfate solution).

Both half-cells must be kept at 298 K.

Connect the two solutions with a salt bridge (filter paper soaked in saturated potassium nitrate solution) to complete the circuit.

Connect the copper electrode and the platinum electrode with wires in an external circuit containing a high resistance voltmeter, so that negligible current flows.

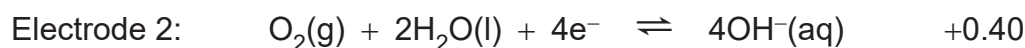
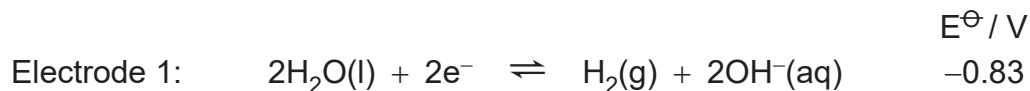
The voltmeter reading is the standard electrode potential of the Cu^{2+}/Cu half-cell (+0.34 V), with copper as the positive electrode.

[6]



(d) A hydrogen-oxygen fuel cell may operate in acidic or alkaline conditions.

The standard electrode potentials involved in the alkaline hydrogen-oxygen fuel cell are:



(i) State and explain which electrode (1 or 2) would be the negative electrode.

Electrode 1, because it has the lower (more negative) $E^\ominus$ value, so oxidation occurs there.

[1]

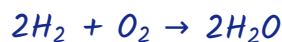
(ii) Calculate the emf of the alkaline hydrogen-oxygen fuel cell.

$$\text{emf} = +0.40 - (-0.83)$$

Answer *+1.23 V*

[1]

(iii) Write an overall equation for the reaction occurring in the cell.



[1]

(iv) Complete the conventional cell representation of the alkaline hydrogen-oxygen fuel cell.



[2]

(v) State one environmental advantage of using a hydrogen-oxygen fuel cell.

It is non-polluting; the only product is water, so no CO_2 is produced.

[1]

[Turn over]

13622.06R

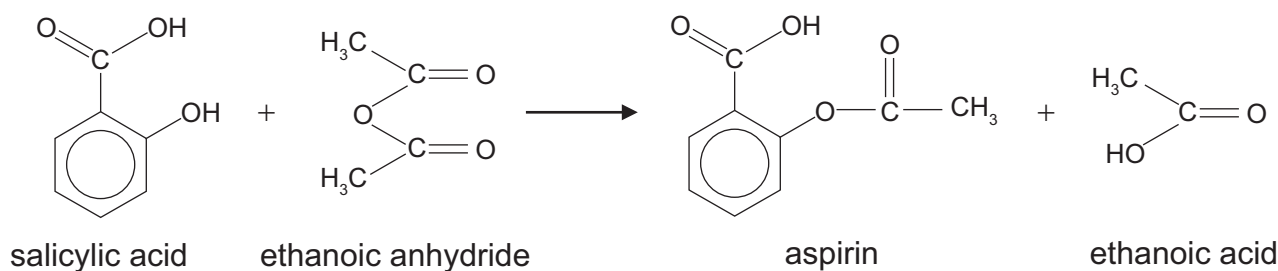


BLANK PAGE
DO NOT WRITE ON THIS PAGE
(Questions continue overleaf)

13622.06R



- 14 Aspirin, $C_9H_8O_4$, may be synthesised in the laboratory using the reaction of salicylic acid with **excess** ethanoic anhydride. The equation for the reaction is given below.

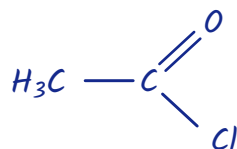


- (a) State the IUPAC name for salicylic acid.

2-hydroxybenzoic acid [1]

- (b) State the IUPAC name and draw the structural formula of another compound which will react with salicylic acid to form aspirin. Explain why ethanoic anhydride is used in preference to this compound.

ethanoyl chloride



Ethanoic anhydride is cheaper, less hazardous and less reactive, so the reaction is less vigorous.

It does not produce corrosive HCl gas. [3]

- (c) Identify the ion which causes the peak at an m/z ratio of 43 in the mass spectrum of ethanoic anhydride.

CH_3CO^+ [1]

[Turn over]



- (d) State the approximate chemical shifts, peak integration and any splitting patterns observed in the ^1H nmr spectrum of ethanoic acid.

chemical shift: 0.5 to 2.0 ppm (CH_3) and 10.0 to 12.0 ppm (COOH)

peak integration: 3 : 1 (CH_3 : COOH)

splitting pattern: two singlets (no H atoms on the adjacent carbon atom) [3]

- (e) Both the $-\text{COOH}$ group and the $-\text{OH}$ group in salicylic acid can ionise in solution.

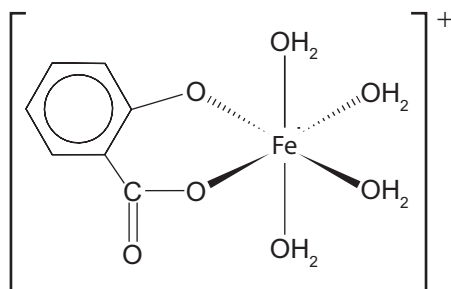
- (i) Write an equation for the ionisation of salicylic acid in which both of these groups are ionised.



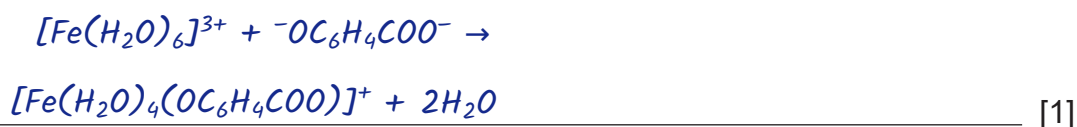
[1]



- (ii) The synthesis of aspirin may be monitored using iron(III) chloride solution. The iron(III) ion forms a purple complex with the completely ionised salicylic acid. This complex is shown below.



Write an ionic equation for the formation of the complex from an aqueous solution of iron(III) ions and the ionised salicylic acid.



- (iii) State the co-ordination number and shape of the complex in (e)(ii).

co-ordination number 6

shape octahedral [2]



- (f) Thin-layer chromatography (TLC) may also be used to monitor the progress of the synthesis of aspirin in the laboratory. The solvent used is ethyl ethanoate.

The chromatogram is dried thoroughly and developed using an alkaline solution of potassium manganate(VII) which stains the TLC plate purple. After strong heating of the TLC plate, most organic compounds show as a yellow/brown spot due to the presence of a mixture of green manganate(VI) ions, MnO_4^{2-} , and black manganese(IV) oxide.

The R_f values for the reactants and products are shown below.

	R_f
salicylic acid	0.315
aspirin	0.800
ethanoic anhydride	0.545
ethanoic acid	0.380

- (i) Write a half-equation for the conversion of manganate(VII) to manganate(VI).



- (ii) Suggest the type of reaction which organic compounds undergo in the presence of alkaline potassium manganate(VII).

oxidation [1]



- (iii) Describe, giving experimental details, how TLC can be carried out on a sample of the reaction mixture and the R_f values calculated and used to determine if the reaction is complete.

In this question you will be assessed on your written communication skills including the use of specialist scientific terms.

Using a pencil, draw a base line about 1 cm from the bottom of the TLC plate.

Using a capillary tube, spot a small sample of the reaction mixture onto the base line (pure salicylic acid and aspirin can be spotted alongside for comparison).

Place the plate in a tank containing a shallow layer of ethyl ethanoate solvent, below the base line, and cover the tank with a lid.

Allow the solvent to run up the plate (over the spots) until it is almost at the top.

Remove the plate, mark the solvent front with a pencil and allow the plate to dry thoroughly.

Develop the plate by dipping it in alkaline potassium manganate(VII) solution and heating strongly, so that yellow/brown spots appear.

Measure the distances moved by each spot and by the solvent from the base line and calculate $R_f = \text{distance moved by spot} \div \text{distance moved by solvent}$.

If there is no spot with $R_f = 0.315$ (salicylic acid), the reaction is complete; the aspirin spot has $R_f = 0.800$.

[6]

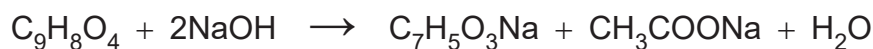
[Turn over]

13622.06R



- (g) 4.50 g of a sample of impure solid aspirin were mixed with an excess of sodium hydroxide in solution (40.0 cm³ of 1.25 mol dm⁻³). The mixture was heated and diluted to 250.0 cm³ using deionised water in a volumetric flask. A 25.0 cm³ sample of the solution was titrated against 0.140 mol dm⁻³ hydrochloric acid using phenolphthalein indicator. 14.3 cm³ of hydrochloric acid were required.

Aspirin reacts with sodium hydroxide according to the equation:



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

pink to colourless

[1]

- (ii) Name the two types of reaction occurring when sodium hydroxide reacts with aspirin.

hydrolysis

neutralisation

[2]

- (iii) Calculate the mass of aspirin in the sample. Give your answer to 3 significant figures.

$$\text{moles HCl} = 14.3 \times 0.140 \div 1000 = 2.002 \times 10^{-3} \text{ mol}$$

$$= \text{moles NaOH remaining in } 25.0 \text{ cm}^3$$

$$\text{moles NaOH remaining in } 250 \text{ cm}^3 = 0.02002 \text{ mol}$$

$$\text{moles NaOH added} = 40.0 \times 1.25 \div 1000 = 0.0500 \text{ mol}$$

$$\text{moles NaOH reacted} = 0.0500 - 0.02002 = 0.02998 \text{ mol}$$

$$\text{moles aspirin} = 0.02998 \div 2 = 0.01499 \text{ mol}$$

$$\text{mass of aspirin} = 0.01499 \times 180 = 2.70 \text{ g}$$

Answer 2.70 g [5]



- (iv) The manufacturer's given value for the percentage of aspirin in the sample was 65%. Calculate the percentage of aspirin in the sample from the titration.

$$\% \text{ aspirin} = 2.70 \div 4.50 \times 100 = 60.0 \%$$

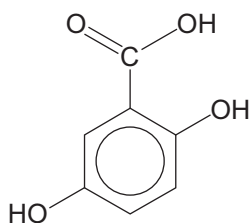
Answer 60.0 % [1]

- (v) Suggest why the value calculated in (g)(iv) may be different to the manufacturer's given value.

Not all of the aspirin was hydrolysed by the sodium hydroxide.

[1]

- (h) Aspirin is metabolised in the liver to form gentisic acid which is excreted by the kidneys in urine as it is more soluble in water than aspirin.



gentisic acid

- (i) Suggest the IUPAC name of gentisic acid.

2,5-dihydroxybenzoic acid

[1]

- (ii) Explain why gentisic acid is more soluble in water than aspirin.

Gentisic acid has more OH groups than aspirin.

So it has a greater ability to form hydrogen bonds with water

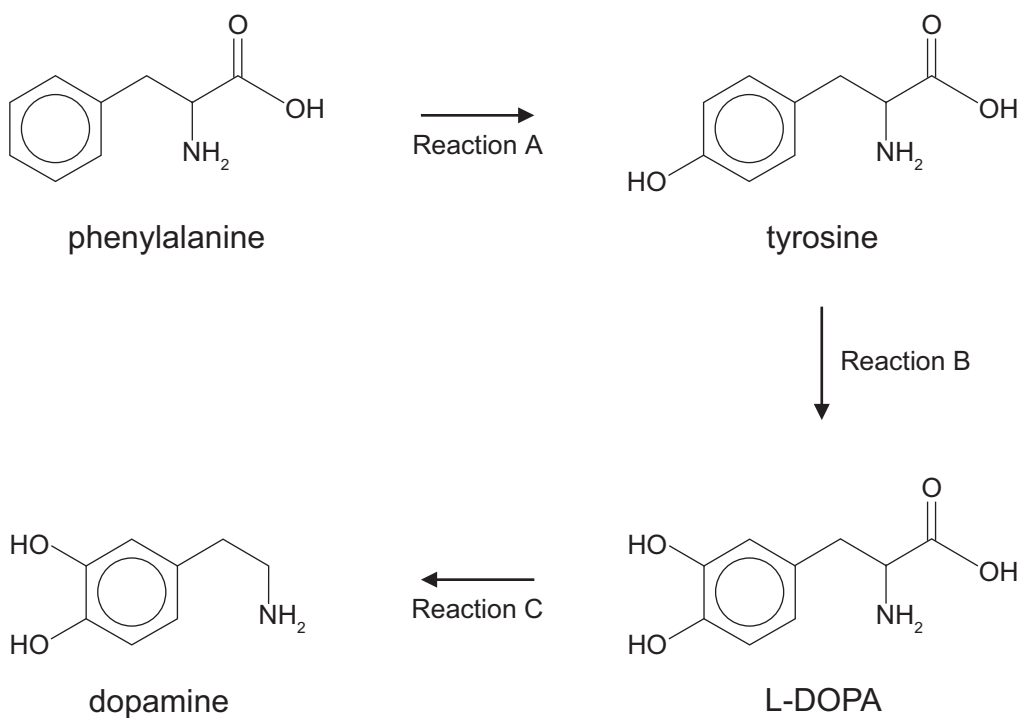
molecules.

[2]

[Turn over]



- 15 Dopamine is a neurotransmitter in the human body. It is synthesised from the amino acid phenylalanine via another amino acid, tyrosine, and L-DOPA.

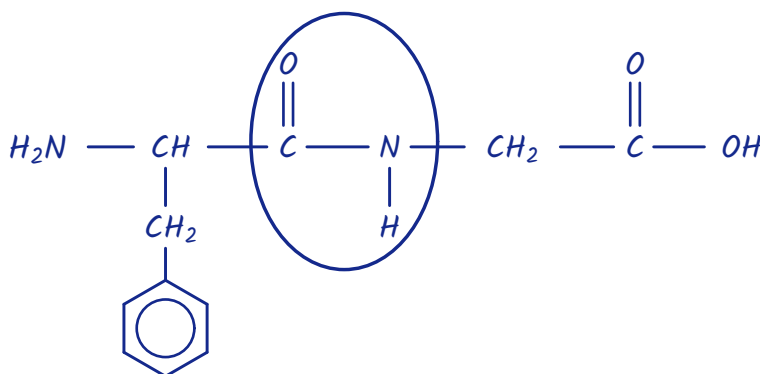


- (a) Suggest the IUPAC name for phenylalanine.

2-amino-3-phenylpropanoic acid

[2]

- (b) Draw the structure of a dipeptide formed between phenylalanine and glycine. Circle the peptide group.



[3]



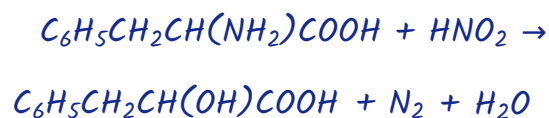
(c) Phenylalanine reacts with nitrous acid.

(i) Name the reagents used to prepare nitrous acid.

sodium nitrite (sodium nitrate(III)) and dilute hydrochloric acid

[1]

(ii) Write an equation for the reaction of nitrous acid with phenylalanine.



[2]

(iii) What is observed during the reaction of nitrous acid with phenylalanine?

Bubbles of gas (effervescence) are seen, as nitrogen is given off.

[1]

(d) Reaction C is a decarboxylation reaction.

(i) Suggest what is meant by decarboxylation.

The removal of a carboxyl group ($-\text{COOH}$) from a molecule, releasing CO_2 .

[1]

(ii) Suggest the name of the inorganic product of this reaction.

carbon dioxide

[1]

(e) (i) Explain why dopamine is not optically active.

It has no chiral centre (no carbon atom bonded to four different groups), so it has no non-superimposable mirror image.

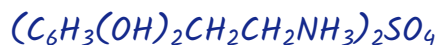
[1]

[Turn over]

13622.06R

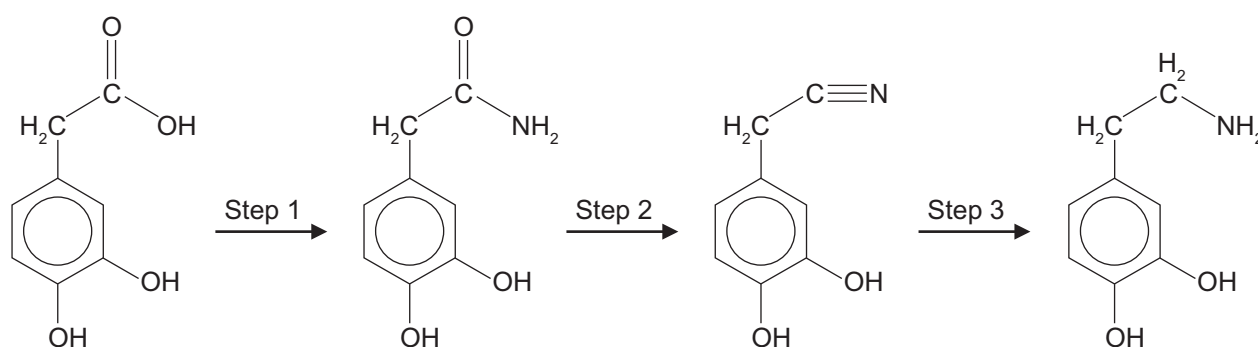


(ii) Write an equation for the reaction of excess dopamine with sulfuric acid.



[2]

(f) Dopamine may be synthesised in the laboratory from (3,4-dihydroxyphenyl)ethanoic acid.



Complete the table below to give the reagents and type of reaction for Steps 2 and 3.

Step	Reagent(s)	Type of reaction
2	phosphorus(V) oxide, P_4O_{10}	dehydration
3	lithal, $LiAlH_4$ (in dry ether)	reduction

[4]





THIS IS THE END OF THE QUESTION PAPER

BLANK PAGE

DO NOT WRITE ON THIS PAGE

13622.06R



DO NOT WRITE ON THIS PAGE

Permission to reproduce all copyright material has been applied for.
In some cases, efforts to contact copyright holders may have been unsuccessful and CCEA
will be happy to rectify any omissions of acknowledgement in future if notified.

ACH24/9
278231



General Information

1 tonne = 10^6 g

1 metre = 10^9 nm

One mole of any gas at 293 K and a pressure of 1 atmosphere (10^5 Pa) occupies a volume of 24 dm³

Avogadro Constant = 6.02×10^{23} mol⁻¹

Planck Constant = 6.63×10^{-34} Js

Specific Heat Capacity of water = $4.2 \text{ J g}^{-1} \text{ K}^{-1}$

Speed of Light = $3 \times 10^8 \text{ m s}^{-1}$



Characteristic absorptions in IR spectroscopy

Wavenumber/cm ⁻¹	Bond	Compound
550–850	C–X (X = Cl, Br, I)	Haloalkanes
750–1100	C–C	Alkanes, alkyl groups
1000–1300	C–O	Alcohols, esters, carboxylic acids
1450–1650	C=C	Arenes
1600–1700	C=C	Alkenes
1650–1800	C=O	Carboxylic acids, esters, aldehydes, ketones, amides, acyl chlorides
2200–2300	C≡N	Nitriles
2500–3200	O–H	Carboxylic acids
2750–2850	C–H	Aldehydes
2850–3000	C–H	Alkanes, alkyl groups, alkenes, arenes
3200–3600	O–H	Alcohols
3300–3500	N–H	Amines, amides

Proton Chemical Shifts in Nuclear Magnetic Resonance Spectroscopy (relative to TMS)

Chemical Shift	Structure	
0.5–2.0	–CH	Saturated alkanes
0.5–5.5	–OH	Alcohols
1.0–3.0	–NH	Amines
2.0–3.0	–CO–CH	Ketones
	–N–CH	Amines
	C ₆ H ₅ –CH	Arene (aliphatic on ring)
2.0–4.0	X–CH	X = Cl or Br (3.0–4.0) X = I (2.0–3.0)
4.5–6.0	–C=CH	Alkenes
5.5–8.5	RCONH	Amides
6.0–8.0	–C ₆ H ₅	Arenes (on ring)
9.0–10.0	–CHO	Aldehydes
10.0–12.0	–COOH	Carboxylic acids

These chemical shifts are concentration and temperature dependent and may be outside the ranges indicated above.

© CCEA 2017

COUNCIL FOR THE CURRICULUM, EXAMINATIONS AND ASSESSMENT

29 Clarendon Road, Clarendon Dock, Belfast BT1 3BG

Tel: +44 (0)28 9026 1200 Fax: +44 (0)28 9026 1234

Email: info@ccea.org.uk Web: www.ccea.org.uk



Data Leaflet

Including the Periodic Table of the Elements

For the use of candidates taking
Advanced Subsidiary and
Advanced Level Examinations

Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations

gce a/as examinations chemistry

THE PERIODIC TABLE OF ELEMENTS																	
Group																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen												4 He Helium					
7 Li Lithium	9 Be Beryllium											11 B Boron	12 C Carbon	14 N Nitrogen	16 O Oxygen	19 F Fluorine	20 Ne Neon
23 Na Sodium	24 Mg Magnesium											27 Al Aluminium	28 Si Silicon	31 P Phosphorus	32 S Sulfur	35.5 Cl Chlorine	40 Ar Argon
39 K Potassium	40 Ca Calcium	45 Sc Scandium	48 Ti Titanium	51 V Vanadium	52 Cr Chromium	55 Mn Manganese	56 Fe Iron	59 Co Cobalt	59 Ni Nickel	64 Cu Copper	65 Zn Zinc	70 Ga Gallium	73 Ge Germanium	75 As Arsenic	79 Se Selenium	80 Br Bromine	84 Kr Krypton
85 Rb Rubidium	88 Sr Strontium	89 Y Yttrium	91 Zr Zirconium	93 Nb Niobium	96 Mo Molybdenum	98 Tc Technetium	101 Ru Ruthenium	103 Rh Rhodium	106 Pd Palladium	108 Ag Silver	112 Cd Cadmium	115 In Indium	119 Sn Tin	122 Sb Antimony	128 Te Tellurium	127 I Iodine	131 Xe Xenon
133 Cs Caesium	137 Ba Barium	139 La [*] Lanthanum	178 Hf Hafnium	181 Ta Tantalum	184 W Tungsten	186 Re Rhenium	190 Os Osmium	192 Ir Iridium	195 Pt Platinum	197 Au Gold	201 Hg Mercury	204 Tl Thallium	207 Pb Lead	209 Bi Bismuth	210 Po Polonium	210 At Astatine	222 Rn Radon
223 Fr Francium	226 Ra Radium	227 Ac [†] Actinium	261 Rf Rutherfordium	262 Db Dubnium	266 Sg Seaborgium	264 Bh Bohrium	277 Hs Hassium	268 Mt Meitnerium	271 Ds Darmstadtium	272 Rg Roentgenium	285 Cn Copernicium						
			140 Ce Cerium	141 Pr Praseodymium	144 Nd Neodymium	145 Pm Promethium	150 Sm Samarium	152 Eu Europium	157 Gd Gadolinium	159 Tb Terbium	162 Dy Dysprosium	165 Ho Holmium	167 Er Erbium	169 Tm Thulium	173 Yb Ytterbium	175 Lu Lutetium	
			232 Th Thorium	231 Pa Protactinium	238 U Uranium	237 Np Neptunium	242 Pu Plutonium	243 Am Americium	247 Cm Curium	245 Bk Berkelium	251 Cf Californium	254 Es Einsteinium	253 Fm Fermium	256 Md Mendelevium	254 No Nobelium	257 Lr Lawrencium	
			90	91	92	93	94	95	96	97	98	99	100	101	102	103	
			* 58 – 71 Lanthanum series † 90 – 103 Actinium series														
			a X b a = relative atomic mass (approx) x = atomic symbol b = atomic number														