



Rewarding Learning

ADVANCED
General Certificate of Education
2022

Centre Number

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Candidate Number

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Chemistry

StemUp Model Solution

Assessment Unit A2 2

assessing

Analytical, Transition Metals,
Electrochemistry and Further
Organic Chemistry



[ACH24]

ACH24

TUESDAY 14 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 **14(d)** and **15(b)(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.

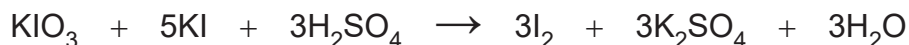


Section A

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.

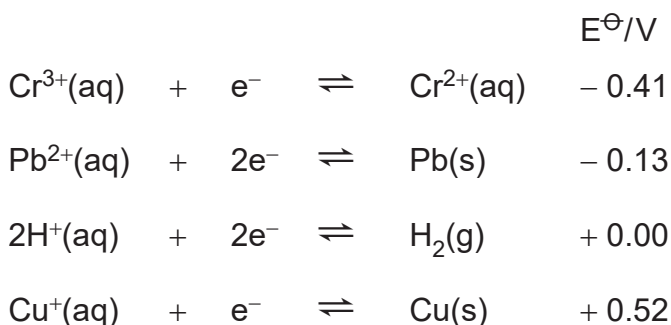
- 1 Which one of the following is the reducing agent in the reaction below?



- A iodate(V) ions
- B iodide ions
- C potassium ions
- D sulfate(VI) ions

Answer B [1]

- 2 Using the standard electrode potentials given below:



Identify the reaction which would be expected to occur.

- A $2\text{Cr}^{2+}(\text{aq}) + \text{Pb}^{2+}(\text{aq}) \rightarrow 2\text{Cr}^{3+}(\text{aq}) + \text{Pb}(\text{s})$
- B $2\text{Cu}(\text{s}) + \text{Pb}^{2+}(\text{aq}) \rightarrow 2\text{Cu}^+(\text{aq}) + \text{Pb}(\text{s})$
- C $\text{Pb}(\text{s}) + 2\text{Cr}^{3+}(\text{aq}) \rightarrow 2\text{Cr}^{2+}(\text{aq}) + \text{Pb}^{2+}(\text{aq})$
- D $\text{Pb}^{2+}(\text{aq}) + \text{H}_2(\text{g}) \rightarrow 2\text{H}^+(\text{aq}) + \text{Pb}(\text{s})$

Answer A [1]



- 3 A gaseous compound of nitrogen and oxygen was completely decomposed into its elements.



60 cm³ of the compound (N_xO_y) were decomposed and the total volume of gas produced was 90 cm³ which was reduced to 60 cm³ after passage over heated copper to remove oxygen. All volumes were measured at room temperature and pressure.

What is the formula of N_xO_y?

- A NO
- B NO₂
- C N₂O
- D N₂O₂

Answer C [1]

- 4 Which one of the following is produced when a solid mixture of ethanamide and P₄O₁₀ is heated?

- A aminoethanoic acid
- B ethanenitrile
- C ethanoic acid
- D ethylamine

Answer B [1]

[Turn over]

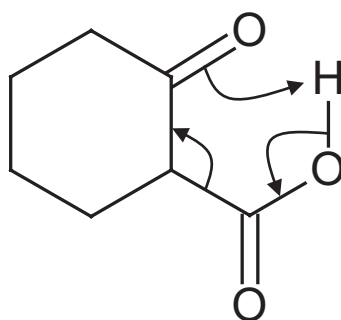


- 5 Which one of the following peaks is present in the mass spectrum of propan-1-ol but **not** present in the mass spectrum of propan-2-ol?

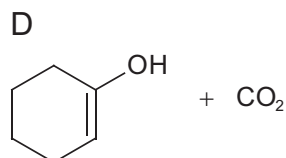
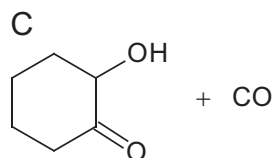
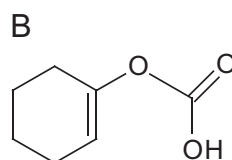
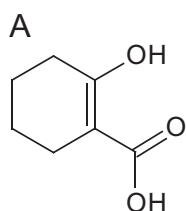
- A $m/z = 15$
B $m/z = 31$
C $m/z = 45$
D $m/z = 60$

Answer B [1]

- 6 The curly arrows below represent the movement of electrons in a mechanism for a chemical reaction.



Which one of the following would be the product(s) from this reaction?



Answer D [1]



- 7 The ^1H nmr spectrum of 1,1-dibromoethane consists of two well-separated signals, one with an integration of 1 and the other with an integration of 3. Which one of the following is correct?

	Signal with integration of 1	Signal with integration of 3
A	doublet	quartet
B	singlet	triplet
C	triplet	singlet
D	quartet	doublet

Answer D [1]

- 8 How many aromatic compounds with the molecular formula $\text{C}_6\text{H}_4\text{Br}_2$ exist?

- A 1
B 2
C 3
D 4

Answer C [1]

- 9 An unknown compound has a molecular ion at $m/z = 79$. Analysis shows its composition to be 17.7% nitrogen by mass. What is its molecular formula?

- A C_3HN_3
B $\text{C}_4\text{H}_3\text{N}_2$
C $\text{C}_4\text{H}_{15}\text{N}$
D $\text{C}_5\text{H}_5\text{N}$

Answer D [1]

[Turn over]



10 Which one of the following statements is the definition of the base peak in a mass spectrum?

- A The highest mass ion
- B The peak of greatest abundance
- C The lowest m/z peak
- D The molecular ion peak

Answer **B** [1]





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Section B

Answer **all five** questions in this section

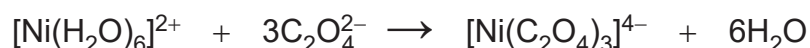
- 11 The ethanedioate ion, $\text{C}_2\text{O}_4^{2-}$, may act as a bidentate ligand. Ethanedioate ions, $\text{C}_2\text{O}_4^{2-}$, can be titrated using manganate(VII) ions in solution.

- (a) Explain the term **bidentate ligand**.

A bidentate ligand is an ion or molecule which uses two lone pairs of electrons to form two co-ordinate (dative) bonds to the central metal ion in a complex.

[2]

- (b) The reaction below occurs when a solution containing ethanedioate ions is added to a solution containing hexaaquanickel(II) ions.



- (i) Suggest why the enthalpy change for this reaction is approximately zero.

The same number and type of bonds are broken and formed: six Ni-O co-ordinate bonds broken and six formed.

[2]

- (ii) Explain, with reference to the equation, why this reaction occurs despite the enthalpy change being approximately zero.

There is an increase in entropy, since there are 4 species on the left and 7 species on the right of the equation.

[2]



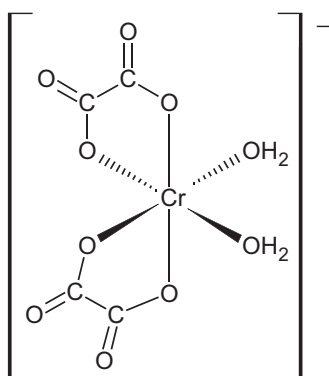
- (iii) State the co-ordination number and oxidation state of nickel and the shape of the $[\text{Ni}(\text{C}_2\text{O}_4)_3]^{4-}$ complex.

co-ordination number: 6

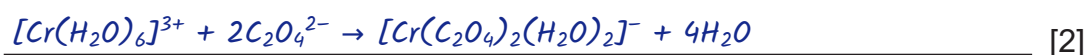
oxidation state of nickel: +2

shape of complex: octahedral [3]

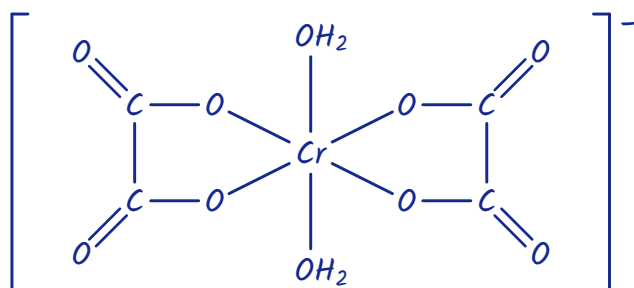
- (c) Hexaaquachromium(III) ions react with ethanedioate ions in solution. The complex formed is shown below. This complex exhibits isomerism. The cis (Z) isomer is shown below and is blue-grey in solution. The trans (E) isomer is purple in solution.



- (i) Write an equation for the formation of this complex from hexaaquachromium(III) ions.



- (ii) Suggest the structure of the trans (E) isomer.



[1]

[Turn over]



- (d) A 25.0 cm^3 portion of a solution of iron(II) ethanedioate was acidified using an excess of sulfuric acid and titrated with $0.0150 \text{ mol dm}^{-3}$ potassium manganate(VII) solution.

The overall equation for the reaction is:



- (i) Explain in terms of oxidation states why this is a redox reaction.

Fe is oxidised from +2 (in FeC_2O_4) to +3 (in $\text{Fe}_2(\text{SO}_4)_3$).

Mn is reduced from +7 (in KMnO_4) to +2 (in MnSO_4).

C is oxidised from +3 (in $\text{C}_2\text{O}_4^{2-}$) to +4 (in CO_2).

Redox: oxidation and reduction occur in the same reaction.

[4]

- (ii) Write three half-equations to show the oxidation and reduction reactions occurring in this overall reaction.



[3]



- (iii) State the colour change which would be observed at the end point during this titration.

colourless to pink

[1]

- (iv) The mean titre was found to be 12.45 cm^3 . Calculate the concentration of the iron(II) ethanedioate solution in mol dm^{-3} . Give your answer to an appropriate number of significant figures.

$$\text{moles MnO}_4^- = 12.45 \times 0.0150 \div 1000 = 1.8675 \times 10^{-4} \text{ mol}$$

$$\text{moles FeC}_2\text{O}_4 = 1.8675 \times 10^{-4} \times 10 \div 6 = 3.1125 \times 10^{-4} \text{ mol}$$

$$\text{concentration} = 3.1125 \times 10^{-4} \times 1000 \div 25.0 = 3.1125 \times 10^{-4} \times 40$$

$$= 0.0125 \text{ mol dm}^{-3} \text{ (3 sig fig)}$$

[4]

- (v) The iron(II) ethanedioate solution was originally made by dissolving 0.561 g of hydrated iron(II) ethanedioate ($\text{FeC}_2\text{O}_4 \cdot x\text{H}_2\text{O}$) in 250 cm^3 of deionised water. Calculate the value of x in $\text{FeC}_2\text{O}_4 \cdot x\text{H}_2\text{O}$.

$$\text{moles FeC}_2\text{O}_4 \text{ in } 250 \text{ cm}^3 = 0.0125 \div 4 = 3.125 \times 10^{-3} \text{ mol}$$

$$M_r \text{ of FeC}_2\text{O}_4 \cdot x\text{H}_2\text{O} = 0.561 \div 3.125 \times 10^{-3} = 180$$

$$M_r \text{ of } x\text{H}_2\text{O} = 180 - 144 = 36$$

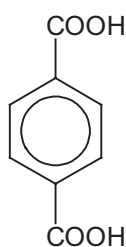
$$x = 36 \div 18 = 2$$

[3]

[Turn over]



- 12 Benzene-1,4-dicarboxylic acid may be used to synthesise polyamide and polyester polymers.



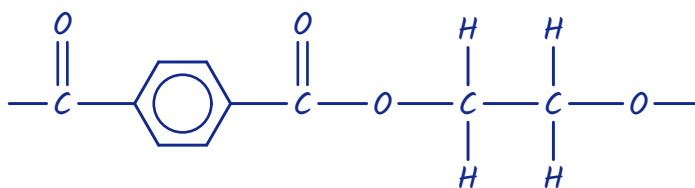
benzene-1,4-dicarboxylic acid

- (a) (i) Name the polyester formed from benzene-1,4-dicarboxylic acid and ethane-1,2-diol.

polyethylene terephthalate (PET, Terylene)

[1]

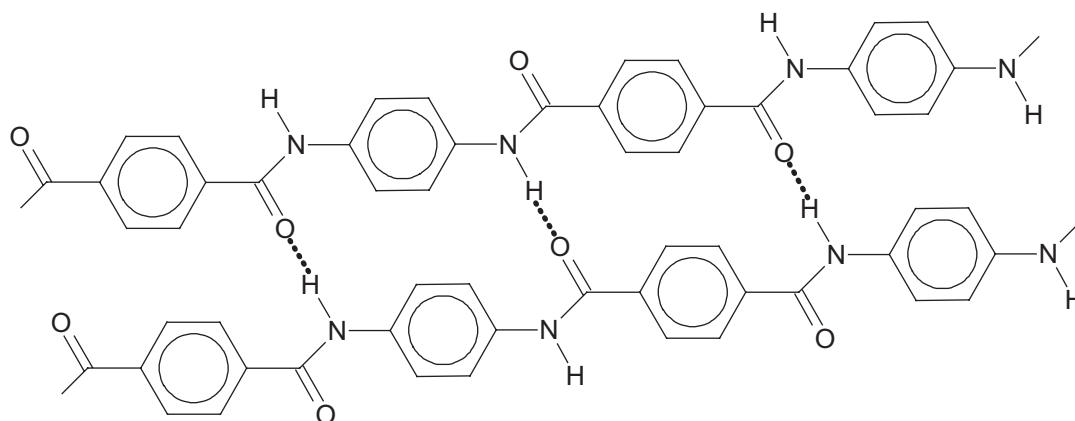
- (ii) Draw one repeating unit of the polyester named in (a)(i).



[1]



- (b) The polyamide Kevlar is made from the reaction of 1,4-diaminobenzene with benzene-1,4-dicarboxylic acid. The melting point of Kevlar is over 500 °C. The diagram below shows two Kevlar polymer chains.



- (i) Suggest the type of bond represented by the dotted lines in the diagram above.

hydrogen bonds

[1]

- (ii) Explain, using the diagram above, why Kevlar has such a high melting point.

There are many strong hydrogen bonds between the chains, which need a substantial amount of energy to break.

[1]

- (c) Explain why polyamides and polyesters are biodegradable.

The amide and ester groups (links) can be hydrolysed by the action of microorganisms.

[2]

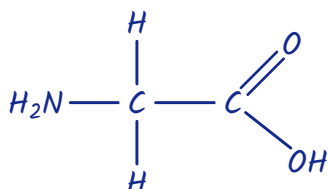
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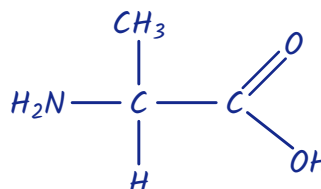
- 13 α -amino acids are compounds which have a carboxylic acid group and an amino group bonded to the same carbon atom.

(a) Draw the structure of the amino acids, glycine and alanine.

glycine

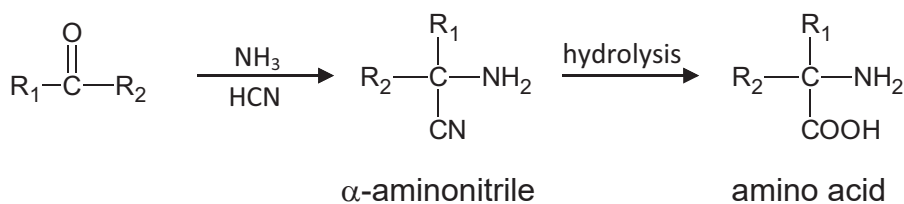


alanine



[2]

- (b) The Strecker synthesis involves the reaction of aldehydes or ketones with ammonia and hydrogen cyanide to form an α -aminonitrile which is hydrolysed to form an amino acid.



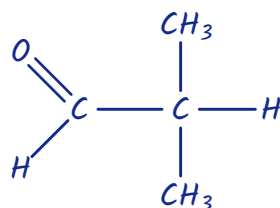
- (i) State the IUPAC name of the amino acid which is formed via the Strecker synthesis from propanone.

2-amino-2-methylpropanoic acid

[2]



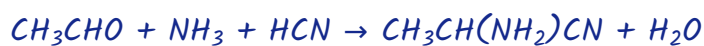
- (ii) Draw the structure and state the IUPAC name of the aldehyde or ketone needed to form the amino acid valine, $(\text{CH}_3)_2\text{CHCH}(\text{NH}_2)\text{COOH}$, via the Strecker synthesis.



2-methylpropanal

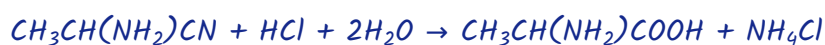
[2]

- (iii) Write an equation for the reaction of ethanal with ammonia and hydrogen cyanide to form the α -aminonitrile.



[1]

- (iv) Write an equation for the hydrolysis of the α -aminonitrile formed in (b)(iii) above using hydrochloric acid.

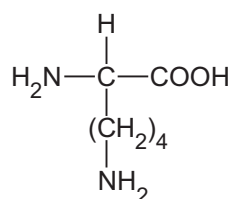


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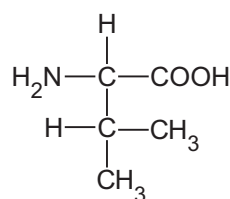
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(c) The structures of the amino acids lysine and valine are shown below.

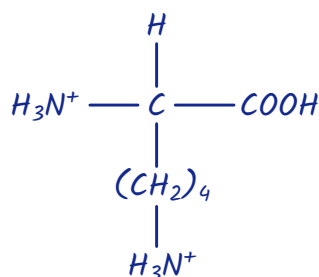


lysine



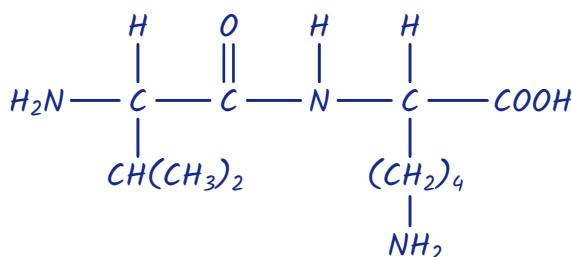
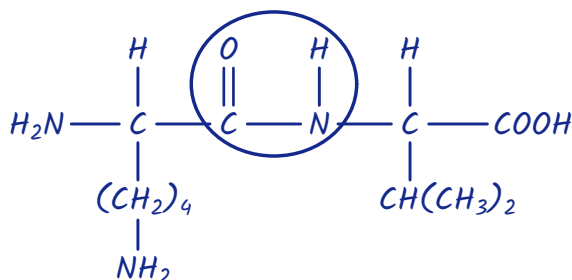
valine

(i) Draw the structure of lysine in solution at pH 1.



[1]

(ii) Draw the structures of two possible dipeptides formed between one molecule of lysine and one molecule of valine. Circle the peptide link in one of the structures you have drawn.



[3]



- (d) Chains of amino acids, bonded by peptide links, form the primary structure of proteins. Describe the secondary structure of proteins.

The chain of amino acids twists or coils (or folds) to form an α -helix or a β -pleated sheet.

This is held in place by intramolecular hydrogen bonds between the C=O and N-H groups of the peptide links.

[3]

- (e) Two-way paper chromatography can be used to separate and identify lysine and valine from a mixture of amino acids.

- (i) Describe how two-way paper chromatography is used to separate lysine and valine from the mixture of amino acids.

Using a pencil, draw a base line close to the bottom of a square of chromatography paper.

Spot a small amount of the amino acid mixture onto one corner of the base line using a capillary tube and allow it to dry.

Place the paper in a tank containing the first solvent (below the base line), cover with a lid and allow the solvent to run up the paper.

Remove the paper, mark the solvent front in pencil and allow the paper to dry.

Rotate the paper by 90° and run it in a second, different solvent, then mark the second solvent front and dry.

[5]

[Turn over]



- (ii) Describe how lysine and valine may be located and identified from the chromatogram.

Locate the spots by spraying with ninhydrin (or use UV light).

Measure the distances travelled by the spots and by the solvents.

Calculate $R_f = \text{distance moved by spot} \div \text{distance moved by solvent}$.

Compare with known R_f values to identify lysine and valine.

[4]

- (iii) Explain why two-way paper chromatography is a more effective method of separating amino acids than one-way paper chromatography.

It improves the separation: amino acids with similar R_f values in

one solvent are separated by the second solvent.

[1]





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14 Vanadium is a transition metal.

- (a) State what is meant by the term **transition metal** and explain using electronic configuration why vanadium is a transition metal.

A transition metal is an element which forms at least one stable ion

with a partially filled d-subshell.

V^{3+} is $[Ar] 3d^2$ (V^{2+} is $[Ar] 3d^3$): the 3d subshell is partially filled.

[2]

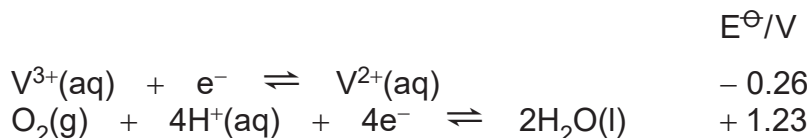
- (b) Complete the table below by giving the half-equations and the colour changes for the reduction reactions given.

Reduction reaction	Half-equation	Colour change
VO_2^+ to VO^{2+}	$VO_2^+ + 2H^+ + e^- \rightarrow VO^{2+} + H_2O$	<i>yellow to blue</i>
VO^{2+} to V^{3+}	$VO^{2+} + 2H^+ + e^- \rightarrow V^{3+} + H_2O$	<i>blue to green</i>
V^{3+} to V^{2+}	$V^{3+} + e^- \rightarrow V^{2+}$	<i>green to violet</i>

[5]



- (c) V^{2+} is a powerful reducing agent and is oxidised by oxygen in the presence of acid to V^{3+} . The half-equations with their standard electrode potentials are shown below.



- (i) Write the ionic equation for the oxidation of V^{2+} using oxygen in the presence of acid.



- (ii) Write the conventional cell representation for the cell which would be set up using the half cells associated with these two half-equations.



- (iii) State and explain, in terms of electrons, which half cell is the negative electrode in the cell.

The V^{2+}/V^{3+} half cell, because oxidation occurs there: V^{2+} loses
electrons, which flow out of this electrode. [2]

- (iv) Calculate the emf of the cell.

$emf = +1.23 - (-0.26)$
 $= +1.49 V$ [1]

[Turn over]



- (d) Describe how you would set up a standard hydrogen electrode and use it to measure the standard electrode potential of $\text{VO}_2^+(\text{aq})/\text{VO}^{2+}(\text{aq})$.

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

Set up the standard hydrogen electrode by placing a platinum

electrode in a solution of $1.00 \text{ mol dm}^{-3} \text{ H}^+$ ions.

Hydrogen gas is passed (bubbled) over the platinum electrode at 100 kPa pressure.

The temperature is kept at 298 K (25 °C).

In another beaker, place a platinum electrode in a mixture of VO_2^+ and VO^{2+} ions, with both vanadium ion solutions at a concentration of 1.00 mol dm^{-3} .

Connect the two solutions with a salt bridge (filter paper soaked in potassium nitrate).

Connect the two electrodes with wires in an external circuit containing a high resistance voltmeter; the reading is the standard electrode potential of $\text{VO}_2^+/\text{VO}^{2+}$.

[6]

[Turn over





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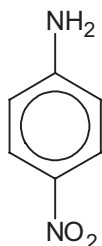
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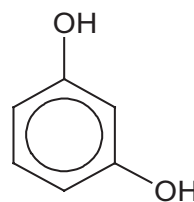


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- 15 The azo dye magneson I is also called azo violet as it is violet in colour. It is prepared from 4-nitrophenylamine and resorcinol.



4-nitrophenylamine



resorcinol

- (a) In this preparation, 4-nitrophenylamine is converted into its diazonium ion and reacted with resorcinol.
- (i) State the reagents and conditions required for the formation of the diazonium ion from 4-nitrophenylamine.

sodium nitrite (NaNO_2)

hydrochloric acid

low temperature, below 10°C

[3]

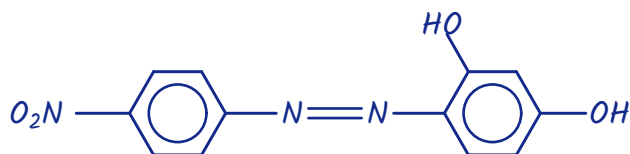
- (ii) Suggest the IUPAC name for resorcinol.

benzene-1,3-diol

[2]



- (iii) Suggest the structure of the azo dye magneson I formed when the diazonium ion of 4-nitrophenylamine reacts with resorcinol.



[2]

- (iv) Explain why magneson I is coloured.

It has an extended delocalised system (rings and N=N group).

This makes the electron energy levels closer together.

So it absorbs light in the visible region of the electromagnetic spectrum.

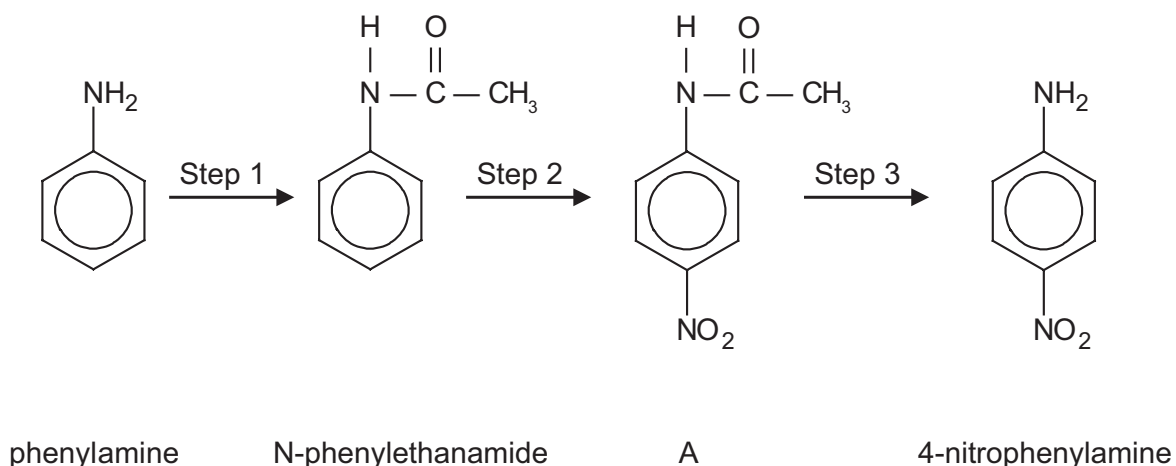
[3]

[Turn over]



- (b) 4-nitrophenylamine cannot be prepared by nitration of phenylamine because the amino group is oxidised by nitric acid. The amino group is therefore protected by converting it to an amide group before the nitration is carried out. The amide group is then hydrolysed.

The following diagram shows the steps in the synthesis



- (i) Name a reagent which could be used to carry out Step 1.

ethanoyl chloride (or ethanoic anhydride) [1]

- (ii) Write the molecular formula for A.

$\text{C}_8\text{H}_8\text{O}_3\text{N}_2$ [1]



- (iii) 4-nitrophenylamine is a solid at room temperature. Describe, giving experimental details, how the 4-nitrophenylamine obtained in Step 3 can be purified. State how the purity of the solid could be confirmed.

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

Dissolve the crude 4-nitrophenylamine in a minimum volume of hot solvent (e.g. ethanol).

Filter the hot solution quickly through fluted filter paper in a pre-warmed funnel to remove insoluble impurities.

Allow the filtrate to cool slowly so that crystals form; soluble impurities stay in solution.

Collect the crystals by suction filtration using a Buchner funnel and wash with a little cold solvent.

Dry the crystals between filter papers or in a desiccator.

Confirm purity by determining the melting point: a pure solid has a sharp melting point (narrow range) which matches the data book value.

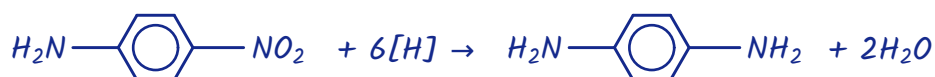
[6]

[Turn over]



(c) 4-nitrophenylamine may be reduced to 1,4-diaminobenzene using tin in concentrated hydrochloric acid. The mixture is heated under reflux for 30 minutes. Sodium hydroxide solution is then added.

- (i) Write an equation, using [H] to represent the reducing agent, for the reduction of 4-nitrophenylamine to 1,4-diaminobenzene.



[2]

- (ii) Explain why sodium hydroxide is added.

To liberate the free amine from its salt (the amine is protonated by the acid).

[1]

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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.

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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 1												4 He Helium 2					
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	98 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La [*] Lanthanum 57	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 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	285 Cn Copernicium 112						
			140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	145 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 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	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	
			^a X ^b a = relative atomic mass (approx) x = atomic symbol b = atomic number														

* 58 – 71 Lanthanum series
† 90 – 103 Actinium series

$\begin{matrix} a \\ \boxed{X} \\ b \end{matrix}$ a = relative atomic mass (approx)
x = atomic symbol
b = atomic number