Rewarding Learning

ADVANCED
General Certificate of Education
2016

Centre Number

Candidate Number

Chemistry

Assessment Unit A2 2

assessing

Analytical, Transition Metals, Electrochemistry and Further Organic Chemistry

[AC222]

AC222

FRIDAY 10 JUNE, AFTERNOON

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 seventeen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all seven** questions in **Section B**. Write your answers in the spaces provided in this question paper.
Do not write outside the boxed area on each page or on blank pages.
Complete in blue or black ink only. **Do not write with a gel pen.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 120.
Quality of written communication will be assessed in Question **16(b)(ii)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures printed down the right-hand side of pages indicate the marks awarded to each question or part question.
A Periodic Table of the Elements, containing some data, is included in this question paper.

10136

Section A

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

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 Which one of the following shows alanine in the solid state?

A H_2NCH_2COOH

B $H_3N^+CH_2COO^-$

C $H_2NCH(CH_3)COOH$

D $H_3N^+CH(CH_3)COO^-$

2 Which one of the following is used to prevent the clotting of blood?

A Cisplatin

B Edta

C Iron(II)

D Iron(III)

3 Which one of the following factors determines the chemical shift in nuclear magnetic resonance spectroscopy?

A The chemical environment of hydrogen atoms

B The fragmentation of hydrogen atoms from the molecule

C The number of chemically equivalent hydrogen atoms

D The ratio of hydrogen atoms

4 In terms of the d sub-shell electronic configurations of ions which one of the following is **not** a transition metal?

A Chromium

B Copper

C Manganese

D Zinc

5 Given the following standard electrode potentials:

$Ca^{2+} + 2e^- \rightleftharpoons Ca$	–2.87 V
$Mn^{2+} + 2e^- \rightleftharpoons Mn$	–1.18 V
$Zn^{2+} + 2e^- \rightleftharpoons Zn$	–0.76 V
$Fe^{2+} + 2e^- \rightleftharpoons Fe$	–0.44 V
$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	+0.77 V
$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$	+1.51 V

which one of the following will reduce MnO_4^- to Mn^{2+} but not to Mn?

A Ca

B Fe^{2+}

C Fe^{3+}

D Zn^{2+}

6 Which one of the following describes the appearance of methyl 3-nitrobenzoate?

A Colourless liquid

B Cream solid

C Orange solid

D Violet crystals

7 Which one of the following is the number of isomeric secondary amines that have a relative molecular mass of 73?

A 1

B 2

C 3

D 4

8 Which one of the following is produced from the alkaline hydrolysis of propanamide?

A Ammonia

B Ammonium chloride

C Propanoic acid

D Water

9 Which one of the following is a feature of HD polythene?

A It has high crystallinity

B It has a highly branched structure

C It is highly flexible

D It is produced at very high pressure

10 Which one of the following will be observed in the nuclear magnetic resonance spectrum of pentan-3-one?

A One doublet and one triplet

B One triplet and one quartet

C Two doublets and two triplets

D Two triplets and two quartets

Section B

Answer **all seven** questions in this section.

11 Complete the following table.

	paper chromatography	**thin-layer chromatography**	**gas-liquid chromatography**
mobile phase	solvent	solvent	
stationary phase	water in paper		oil on solid support
value recorded for analysis	retardation factor (R_f)		

[4]

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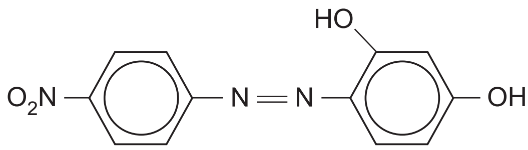
(Questions continue overleaf)

12 Azo violet is a dye that can be formed from 4-nitrophenylamine via the 4-nitrobenzenediazonium ion.



azo violet

(a) (i) Write the molecular formula for azo violet and calculate its relative molecular mass.

____

____ [2]

(ii) Calculate the mass of 4-nitrophenylamine (RMM = 138) required to produce 30 g of azo violet assuming a 60% yield.

____

____

____

____

____ [3]

(b) **(i)** Circle the azo group on the structure. [1]

(ii) Explain why azo violet is coloured.

____

____

____

____ [3]

(c) Draw the structure of the 4-nitrobenzenediazonium ion showing the bonds between the nitrogen atoms.

[2]

(d) State the names of the reagents and the reaction conditions for the formation of the 4-nitrobenzenediazonium ion from 4-nitrophenylamine.

____

____

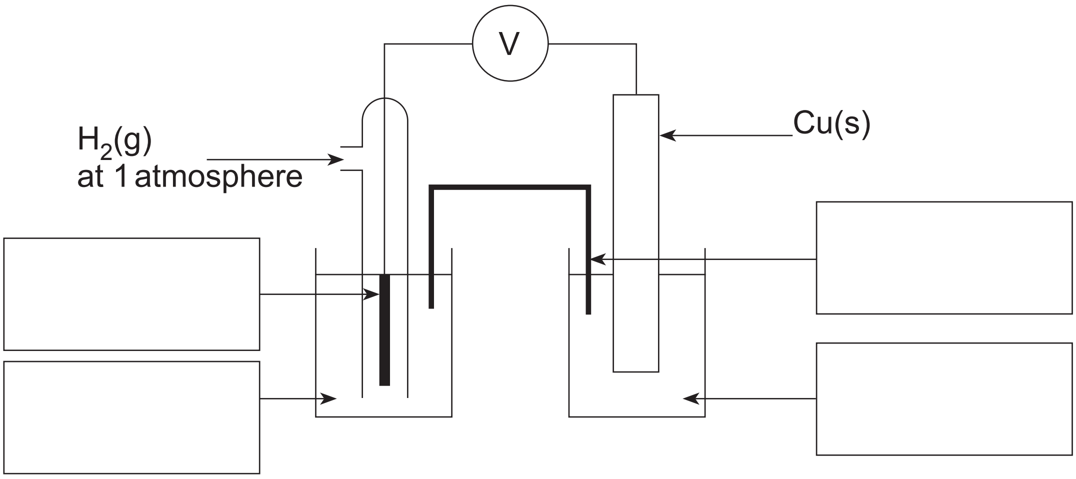
____

____ [3]

[Turn over

13 The standard electrode potential of copper can be determined by connecting a standard hydrogen electrode to a standard copper half-cell.

(a) Complete the labelling of the diagram below.



[4]

(b) The reaction of Cu^{2+} ions with I^- ions produces insoluble copper(I) iodide.

$$2Cu^{2+}(aq) + 4I^-(aq) \rightarrow 2CuI(s) + I_2(aq)$$

What colour change will be observed in the solution during the reaction?

____ [2]

(c) Copper is commonly used in alloys such as brass. The following method describes how a titration can be carried out to determine the approximate percentage of copper in a sample of brass.

- The copper in a 2.0 g sample of brass is oxidised to Cu^{2+} ions by reacting the brass with excess nitric acid.
- Sodium carbonate solution is added to the mixture which is then diluted to 250 cm^3 in a volumetric flask.
- A 25.0 cm^3 portion of this solution is transferred to a conical flask to which excess potassium iodide is added.
- The liberated iodine is titrated against 0.1 mol dm^{-3} sodium thiosulfate solution.

(i) Suggest the purpose of the sodium carbonate solution.

____ [1]

(ii) Write an ionic equation for the reaction of thiosulfate ions with iodine.

____ [2]

(iii) Name the indicator used for the titration and state at what point it is added to the titration mixture.

____

____ [2]

(iv) What colour change takes place at the end point?

____ [1]

(v) 23.8 cm^3 of 0.1 mol dm^{-3} sodium thiosulfate solution are required to react with the liberated iodine produced from a 25.0 cm^3 portion of the solution. Calculate the percentage of copper in the sample of brass.

____

____

____

____

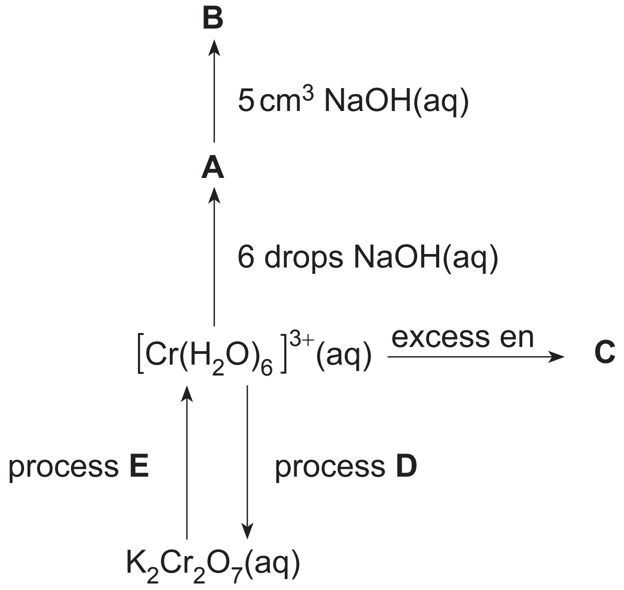
____

____

____

____ [4]

14 A reaction scheme for $[Cr(H_2O)_6]^{3+}$(aq) is shown below.



(a) **(i)** State the colour of solid **A**.

____ [1]

(ii) State the formula of solid **A**.

____ [1]

(b) State the colour of solution **B**.

____ [1]

(c) **(i)** State the formula of the complex ion **C**.

____ [1]

(ii) What is the coordination number of chromium in **C**?

____ [1]

(d) State the reagents required for process **D**.

[3]

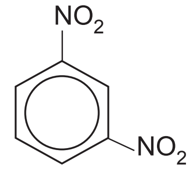
(e) **(i)** Name the reducing agent and state the conditions used in process **E**.

[3]

(ii) Give the oxidation state of chromium before and after process **E**.

[1]

15 (a) Nitrobenzene can be converted to 1,3-dinitrobenzene.



1,3-dinitrobenzene

(i) State the reagents required to convert nitrobenzene into 1,3-dinitrobenzene.

____

____ [2]

(ii) Name the nitrating species and write an equation for its formation.

____

____ [2]

(iii) Write a mechanism for the reaction of nitrobenzene to form 1,3-dinitrobenzene.

[3]

(iv) What is the name of the mechanism for the reaction?

____ [2]

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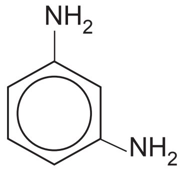
(b) The 1,3-dinitrobenzene can then be converted to 1,3-diaminobenzene.



1,3-diaminobenzene

(i) State the reagents required to convert 1,3-dinitrobenzene to 1,3-diaminobenzene.

____

____ [2]

(ii) Explain why 1,3-diaminobenzene and ethane-1,2-diamine can act as bases.

____

____

____

____

____ [2]

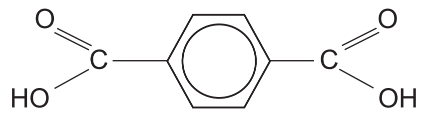
(iii) Explain why 1,3-diaminobenzene is a weaker base than ethane-1,2-diamine.

____

____

____ [1]

(c) Kevlar is a biodegradable polyamide that can be formed from 1,4-diaminobenzene and benzene-1,4-dicarboxylic acid.



benzene-1,4-dicarboxylic acid

(i) Draw the repeating unit of Kevlar and circle the amide bond.

[2]

(ii) Give the structure of a reagent that could be used in place of benzene-1,4-dicarboxylic acid to make Kevlar.

[1]

(iii) Explain why Kevlar is **biodegradable**.

____

____

____ [2]

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(Questions continue overleaf)

16 Edta is a hexadentate ligand that reacts with a solution of copper(II) ions to produce a dark blue solution.

(a) Suggest the meaning of the term **hexadentate**.

____

____

____ [2]

(b) A solution of copper(II) ions reacts with edta according to the following equation.

$$[Cu(H_2O)_6]^{2+} + edta^{4-} \rightarrow [Cu(edta)]^{2-} + 6H_2O$$

(i) Explain, in terms of entropy, why the reaction between $[Cu(H_2O)_6]^{2+}$ and edta takes place.

____

____

____ [2]

(ii) Describe how colorimetry can be used to prove that the ratio of copper(II) to edta in $[Cu(edta)]^{2-}$ is 1:1.

[5]

Quality of written communication [2]

[Turn over

(c) Copper is used to catalyse the decomposition of gaseous propanone to ethenone, $CH_2{=}C{=}O$, and methane.

(i) Write an equation for the decomposition of propanone to ethenone and methane.

____ [1]

(ii) Explain and name the type of catalysis taking place.

____

____

____ [2]

(iii) Explain how transition metals catalyse reactions by chemisorption.

____

____

____

____

____ [3]

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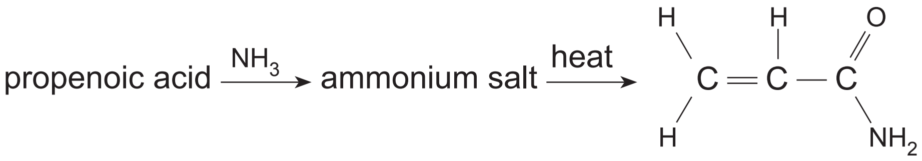
(Questions continue overleaf)

17 Acrylamide is a carcinogen that gets into the body via cigarette smoke and some types of fried food. It is highly soluble in water and can be produced by heating the product from the reaction of propenoic acid with ammonia.



acrylamide

(a) **(i)** Draw the structure of propenoic acid showing all the bonds present.

[1]

(ii) Suggest the formula of the ammonium salt.

____ [1]

(iii) Suggest the name of the ammonium salt.

____ [1]

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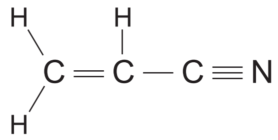
(b) Acrylonitrile can be made from acrylamide.



acrylonitrile

(i) Give the formula of the reagent used to convert acrylamide to acrylonitrile.

____ [1]

(ii) Name the type of reaction taking place.

____ [1]

(iii) With reference to the nmr spectra of both acrylamide and acrylonitrile, explain how nmr could be used to confirm the conversion of acrylamide to acrylonitrile was complete.

____

____

____ [2]

(c) Explain why acrylamide is soluble in water.

____

____

____ [2]

(d) (i) State the expected observations when acrylamide is added to bromine water.

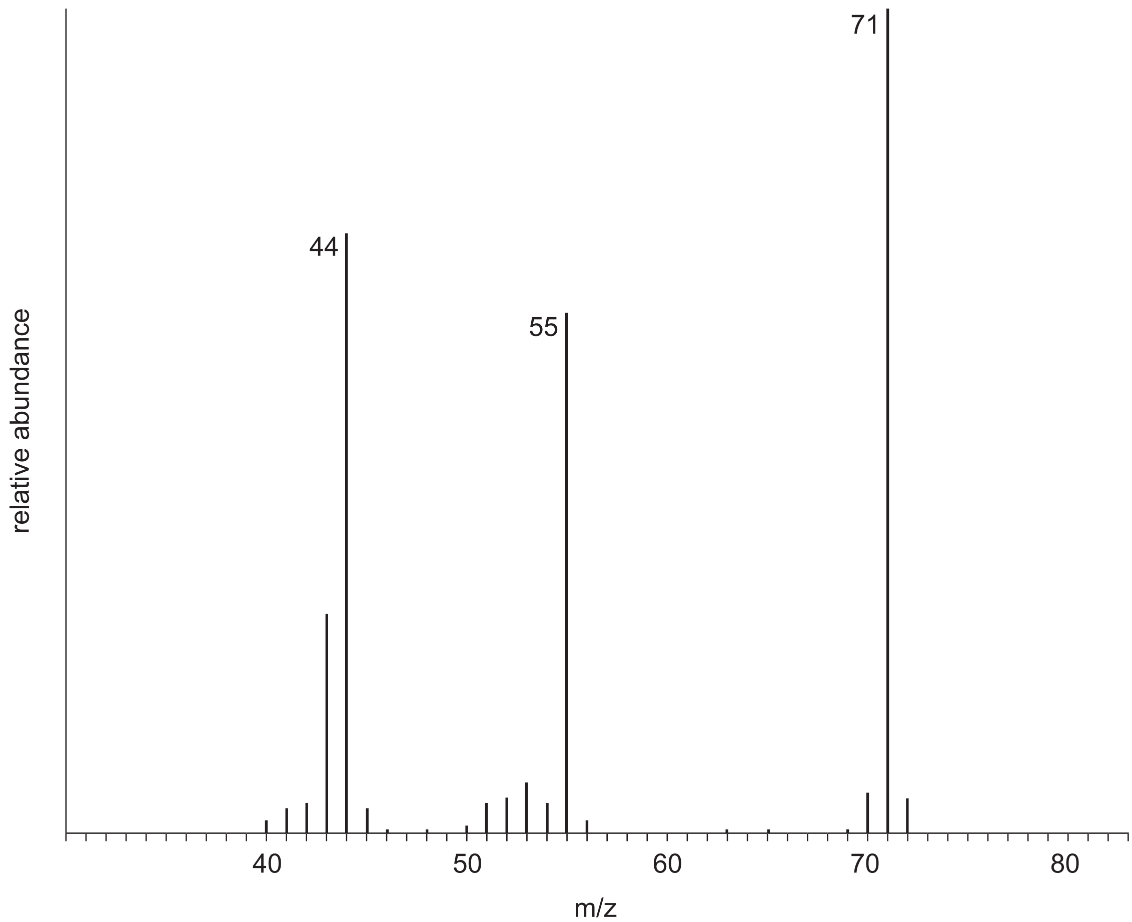
____

____ [1]

(ii) Write the equation for this reaction.

____ [1]

(e) Analysis of acrylamide levels is very important in the food industry. The mass spectrum of acrylamide is shown below.



(i) Give **two** terms which describe the peak at m/z 71.

____

____ [2]

(ii) Explain why there is a peak at m/z 72.

____ [1]

(iii) Give the ion responsible for the peak at m/z 44.

____ [1]

(f) Researchers suggest that the daily intake of acrylamide should not exceed 1.7×10^{-4} moles per kilogram of bodyweight. Calculate the mass of acrylamide, in milligrams, that should not be exceeded by an 80 kg man on a daily basis.

____

____

____ [3]

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For Examiner's use only	
Question Number	**Marks**
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
16	
17	
Total Marks	

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Periodic Table of the Elements

For the use of candidates taking

Advanced Subsidiary and Advanced Level
Chemistry 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

(advanced)

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THE PERIODIC TABLE OF ELEMENTS

Group

One mole of any gas at 20 °C and a pressure of 1 atmosphere (10^5 Pa) occupies a volume of 24 dm^3.

Planck Constant = 6.63×10^{-34} J s

Gas Constant = 8.31 J mol^{-1} K^{-1}

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

I	II											III	IV	V	VI	VII	0
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	99 **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															

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	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

* 58–71 Lanthanum series

† 90–103 Actinium series

a x
b

a = relative atomic mass (approx.)

x = atomic symbol

b = atomic number