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ADVANCED
General Certificate of Education
2016

Centre Number

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Candidate Number

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Chemistry

Assessment Unit A2 2

*assessing*Analytical, Transition Metals,
Electrochemistry
and Further Organic Chemistry

MV18

[AC222]**FRIDAY 10 JUNE, AFTERNOON**

Time

2 hours, plus your additional time allowance.

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.

Complete in blue or black ink only.

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 at the end of each question 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.

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 $\text{H}_2\text{NCH}_2\text{COOH}$
 - B $\text{H}_3\text{N}^+\text{CH}_2\text{COO}^-$
 - C $\text{H}_2\text{NCH}(\text{CH}_3)\text{COOH}$
 - D $\text{H}_3\text{N}^+\text{CH}(\text{CH}_3)\text{COO}^-$
- 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:



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

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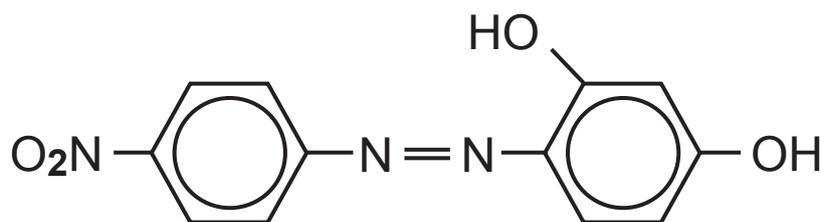
Section B

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

11 Complete the following table. [4 marks]

	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)		

- 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 marks]

- (ii)** Calculate the mass of 4-nitrophenylamine (RMM = 138) required to produce 30g of azo violet assuming a 60% yield. [3 marks]

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

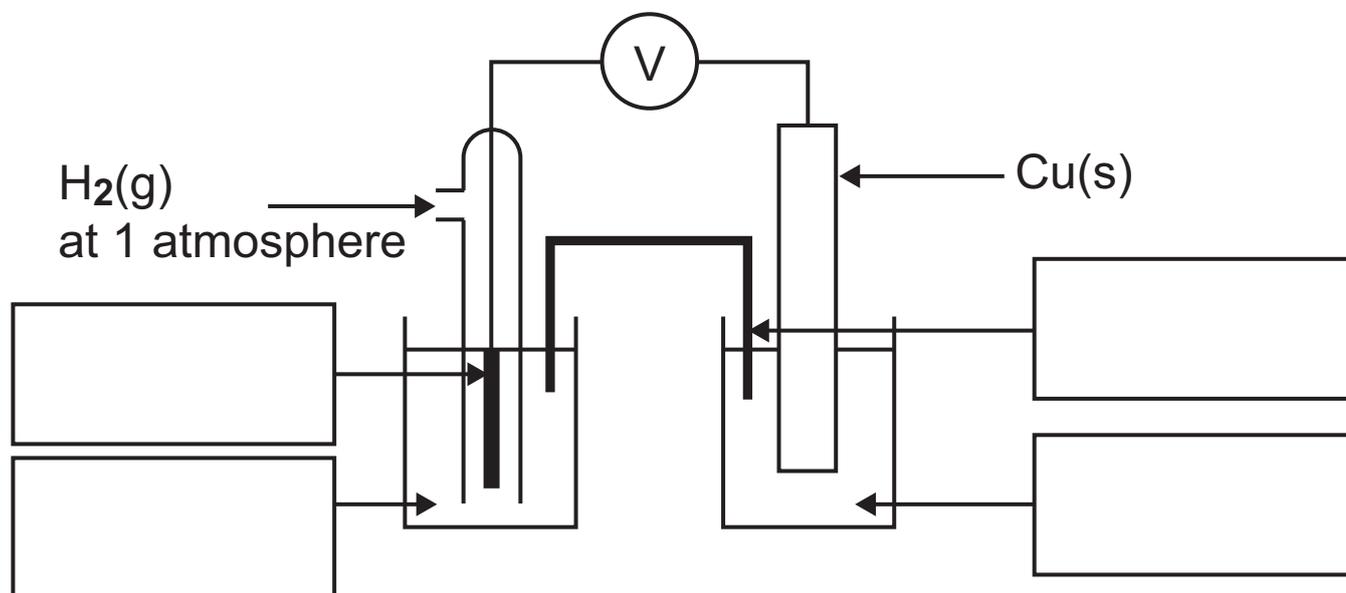
(ii) Explain why azo violet is coloured. [3 marks]

(c) Draw the structure of the 4-nitrobenzenediazonium ion showing the bonds between the nitrogen atoms. [2 marks]

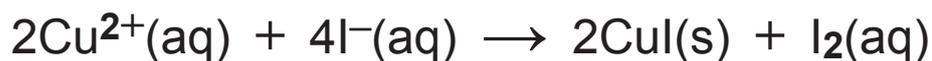
(d) State the names of the reagents and the reaction conditions for the formation of the 4-nitrobenzenediazonium ion from 4-nitrophenylamine. [3 marks]

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 marks]



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



What colour change will be observed in the solution during the reaction? [2 marks]

(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 mark]

(ii) Write an ionic equation for the reaction of thiosulfate ions with iodine. [2 marks]

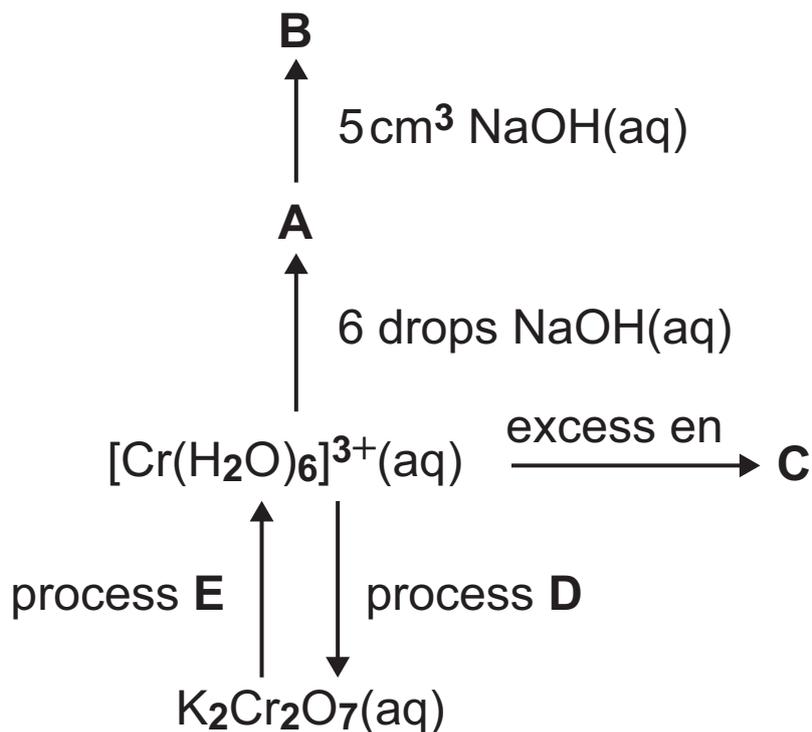
(iii) Name the indicator used for the titration and state at what point it is added to the titration mixture. [2 marks]

(iv) What colour change takes place at the end point? [1 mark]

(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 marks]

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14 A reaction scheme for $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}(\text{aq})$ is shown below.



(a) (i) State the colour of solid **A**. [1 mark]

(ii) State the formula of solid **A**. [1 mark]

(b) State the colour of solution **B**. [1 mark]

(c) (i) State the formula of the complex ion **C**. [1 mark]

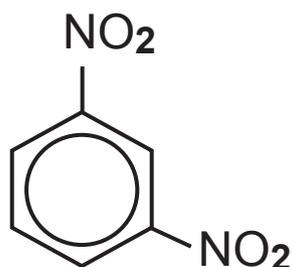
(ii) What is the coordination number of chromium in **C**? [1 mark]

(d) State the reagents required for process **D**. [3 marks]

(e) (i) Name the reducing agent and state the conditions used in process **E**. [3 marks]

(ii) Give the oxidation state of chromium before and after process **E**. [1 mark]

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



1,3-dinitrobenzene

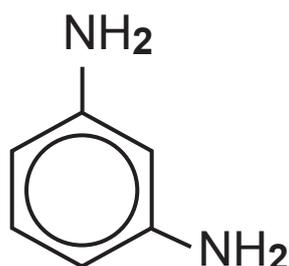
(i) State the reagents required to convert nitrobenzene into 1,3-dinitrobenzene. [2 marks]

(ii) Name the nitrating species and write an equation for its formation. [2 marks]

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

(iv) What is the name of the mechanism for the reaction? [2 marks]

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



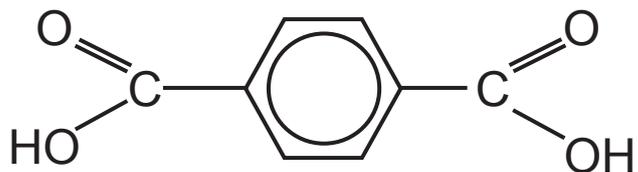
1,3-diaminobenzene

- (i) State the reagents required to convert 1,3-dinitrobenzene to 1,3-diaminobenzene. [2 marks]

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

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

- (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 marks]

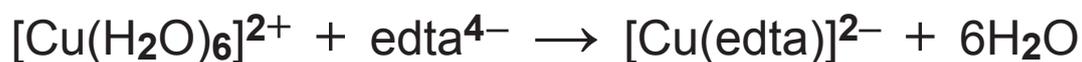
(ii) Give the structure of a reagent that could be used in place of benzene-1,4-dicarboxylic acid to make Kevlar. [1 mark]

(iii) Explain why Kevlar is **biodegradable**. [2 marks]

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 marks]

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



(i) Explain, in terms of entropy, why the reaction between $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ and edta takes place. [2 marks]

(c) Copper is used to catalyse the decomposition of gaseous propanone to ethenone, $\text{CH}_2=\text{C}=\text{O}$, and methane.

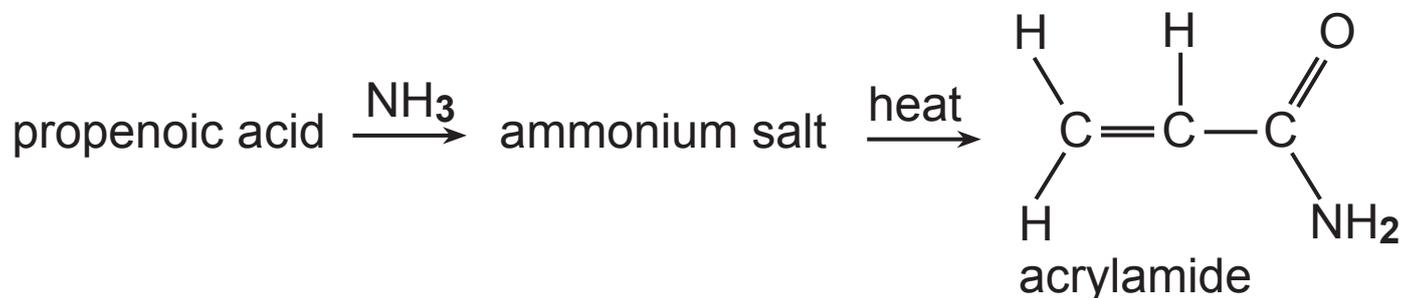
(i) Write an equation for the decomposition of propanone to ethenone and methane. [1 mark]

(ii) Explain and name the type of catalysis taking place. [2 marks]

(iii) Explain how transition metals catalyse reactions by chemisorption. [3 marks]

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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.

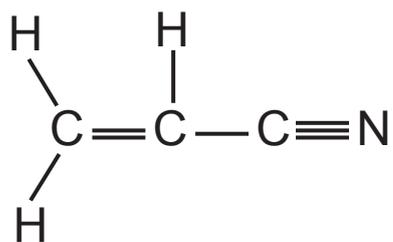


(a) (i) Draw the structure of propenoic acid showing all the bonds present. [1 mark]

(ii) Suggest the formula of the ammonium salt. [1 mark]

(iii) Suggest the name of the ammonium salt. [1 mark]

(b) Acrylonitrile can be made from acrylamide.



acrylonitrile

(i) Give the formula of the reagent used to convert acrylamide to acrylonitrile. [1 mark]

(ii) Name the type of reaction taking place. [1 mark]

(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 marks]

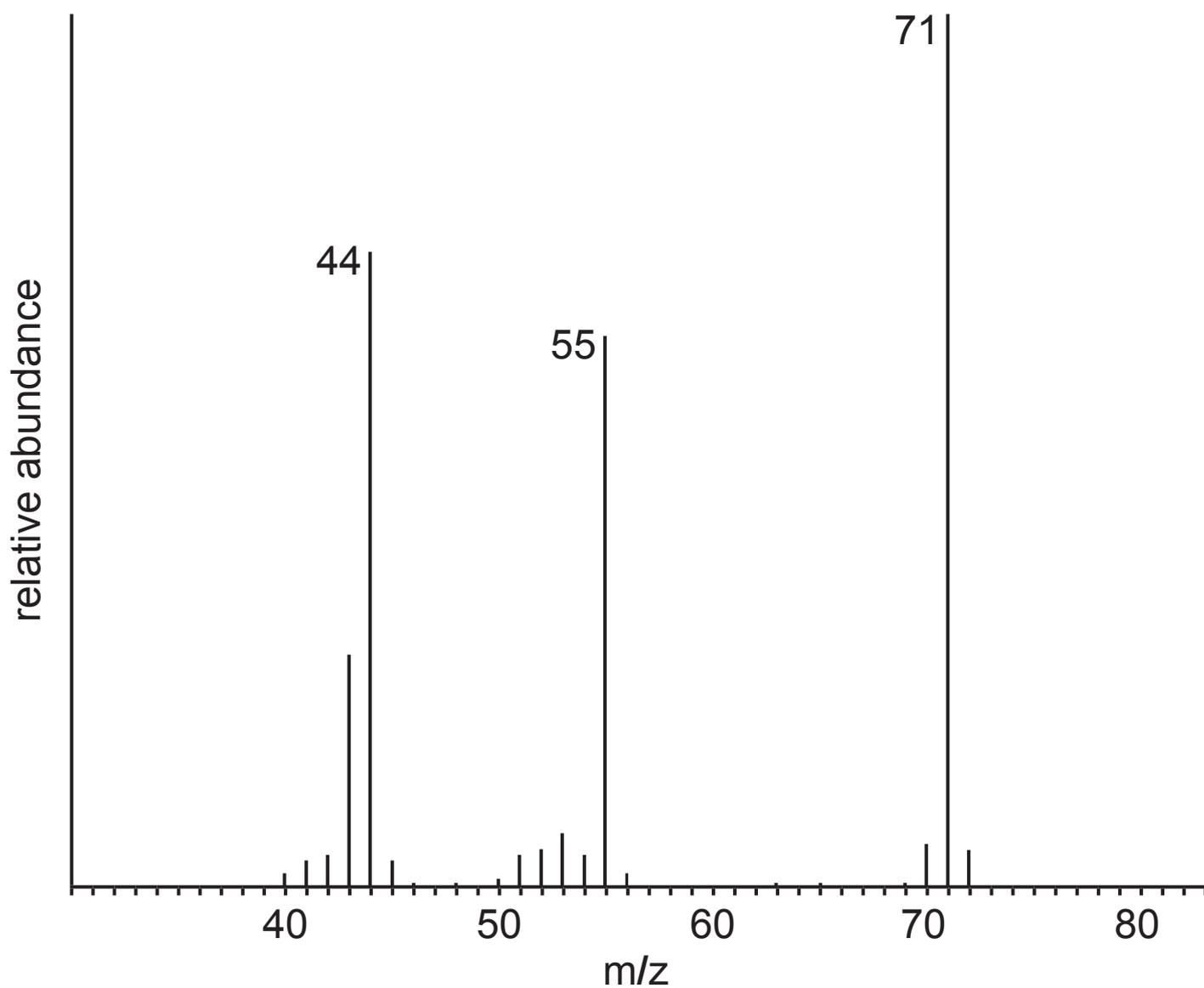
(c) Explain why acrylamide is soluble in water. [2 marks]

(d) (i) State the expected observations when acrylamide is added to bromine water. [1 mark]

(ii) Write the equation for this reaction. [1 mark]

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(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 marks]

(ii) Explain why there is a peak at m/z 72. [1 mark]

(iii) Give the ion responsible for the peak at m/z 44. [1 mark]

(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 marks]

THIS IS THE END OF THE QUESTION PAPER

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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)

I	II	THE PERIODIC TABLE OF ELEMENTS Group										III	IV	V	VI	VII	0						
1 H Hydrogen 1	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 Js Gas Constant = 8.31 J mol ⁻¹ K ⁻¹ Avogadro Constant = 6.02 × 10 ²³ mol ⁻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																					

* 58–71 Lanthanum series

† 90–103 Actinium series

a	x
b	

a = relative atomic mass (approx.)
x = atomic symbol
b = atomic number

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