Surname	Centre Number	Candidate Number
First name(s)		2

GCE AS

B410U10-1

S23-B410U10-1

eduqas
Part of WJEC

TUESDAY, 16 MAY 2023 – MORNING

CHEMISTRY – AS component 1

The Language of Chemistry, Structure of Matter and Simple Reactions

1 hour 30 minutes

	For Examiner's use only		
	Question	Maximum Mark	Mark Awarded
Section A	1. to 6.	10	
Section B	7.	10	
	8.	11	
	9.	16	
	10.	15	
	11.	8	
	12	10	
	Total	80	

B410U101 01

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:
- calculator;
- **Data Booklet** supplied by WJEC.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Section A Answer **all** questions.
Section B Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The assessment of the quality of extended response (QER) will take place in **Q.10**(b).

JUN23B410U10101

 PJ/GJR*(S23-B410U10-1)

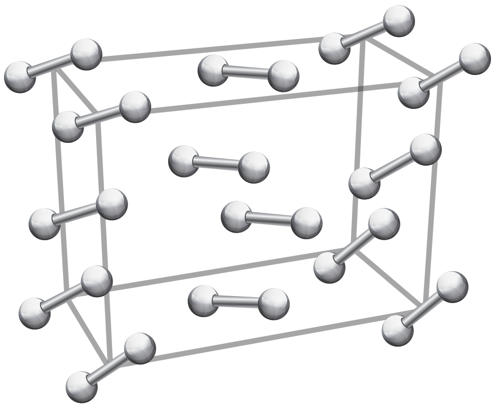
Examiner only

SECTION A

Answer **all** questions.

1. The diagram below shows the arrangement of molecules in a crystal of iodine.

State the two types of bonding that occur in this structure. [1]



.... and ....

2. Bromine is made when chlorine is passed through a solution of potassium bromide.

(a) Write an equation to represent this reaction. [1]

....

(b) State why chlorine is described as an oxidising agent in this reaction. [1]

....

....

Examiner only

3. Actinium-236 has a half-life of 72 s.

Calculate the mass remaining from a 16 g sample after 6 minutes. [1]

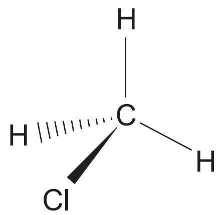
Mass = ... g

4. (a) Explain why some covalent bonds are polar. [1]

....

....

(b) On the diagram below mark the **largest** permanent dipole. [1]



B410U101 03

5. The first eight ionisation energy values for an element are shown below.

State to which group this element belongs. [1]

	1st	2nd	3rd	4th	5th	6th	7th	8th
Ionisation energy / $kJ\,mol^{-1}$	1670	3380	6045	8415	11075	15050	17905	91655

Group ....

Examiner only

6. (a) Give the meaning of the term empirical formula. [1]

....

....

(b) It was found that a compound contained 6.10 g of copper, 5.35 g of iron and 6.16 g of sulfur **only**.

Calculate the empirical formula of this compound. [2]

Empirical formula ....

10

Examiner only

SECTION B

Answer **all** questions.

7. (a) BF_3 and NF_3 have similar molecular formulae.

Explain why the shapes of their molecules are different. [3]

(b) CH_3CH_2OH and CH_3CH_2SH also have similar formulae but they boil at very different temperatures.

Explain the difference in boiling temperatures. [3]

B410U101
05

Examiner only

(c) A student completed two titration experiments but made some fundamental errors in the analysis of the results.

(i) Using the following results from the first experiment he determined the mean volume to be 24.48 cm^3.

Explain the error that he made and calculate the correct value. [2]

Titration	1	2	3
Initial reading / cm^3	0.00	0.30	0.10
Final reading / cm^3	24.85	24.55	24.45
Titre / cm^3	24.85	24.25	24.35

....

....

Correct value = ... cm^3

Examiner only

(ii) In another experiment the student found that 29.95 cm^3 of sulfuric acid of concentration 0.100 mol dm^{-3} neutralised 25.00 cm^3 of an aqueous solution of sodium hydroxide.

$$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$$

He incorrectly calculated the concentration of sodium hydroxide to be 0.120 mol dm^{-3}.

Calculate the correct value and hence identify the student's error. [2]

Correct value = ... mol dm^{-3}

....

....

B410U101 07

10

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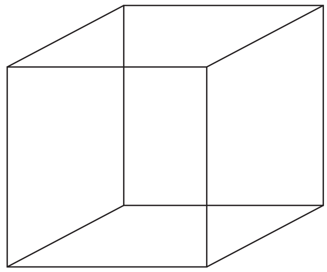
8. Ionic compounds are very useful in everyday life.

(a) Sodium chloride is a white crystalline solid.

Complete and label the diagram below to show the arrangement of ions in the sodium chloride lattice. [1]



(b) For the ionic compound caesium chloride, state the coordination number of the caesium ion **only**. [1]

....

(c) Magnesium oxide is formed from the reaction of magnesium with oxygen.

Using outer electrons only, draw a dot and cross diagram to show the formation of magnesium oxide. [2]

(d) Suggest, with a reason, whether you would expect the coordination of magnesium ions in magnesium oxide to be like that in sodium chloride or that in caesium chloride. [1]

....

....

Examiner only

(e) (i) One of the many uses of magnesium sulfate is as a muscle relaxant and it is one of the components in some mineral bath salts.

Explain why many ionic compounds dissolve easily in water. [2]

....

....

....

....

(ii) State why barium sulfate would not be useful as a bath salt. [1]

....

(iii) A bath contains 0.136 m^3 of water. Calculate the minimum mass of magnesium sulfate needed to make a solution with a concentration of 220 mg dm^{-3}.

Show your working and record your answer to the **appropriate** number of significant figures. [3]

Mass = ... g

B410U101 09

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Examiner only

9. Lithium and rubidium are both Group 1 metals and there are many similarities in their behaviour.

(a) (i) Write an equation for the reaction of lithium with water. [1]

....

(ii) State the trend in reactivity down the group and use this to suggest how the observations made when rubidium reacts with water would differ from those for lithium. [2]

....

....

....

(iii) Calculate the minimum mass of lithium required to produce $50.0\,cm^3$ of hydrogen gas at 25 °C and 1 atm. [2]

Mass = ... g

Examiner only

(b) A student noted that lithium and rubidium give similar colours in flame tests.

(i) State the colour seen. [1]

....

(ii) The flame colour for rubidium corresponds to a wavelength of 780 nm.

Calculate the energy released, in $kJ\,mol^{-1}$, when this colour is observed. [3]

Energy released = ... $kJ\,mol^{-1}$

B410U101 11

Turn over.

Examiner only

(c) (i) Give the electronic structure of the lithium ion formed by the loss of one electron. [1]

....

(ii) Give the meaning of the term first ionisation energy. [1]

....

....

....

(iii) Explain why the first ionisation energies of lithium and rubidium are very different. [2]

....

....

....

....

(d) The flame colours of lithium and rubidium are due to their emission of visible light.

The hydrogen emission spectrum consists of several series of lines. State which series is in the visible region and explain why this series cannot be used to calculate the first ionisation energy of the hydrogen atom. [3]

....

....

....

....

....

....

16

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Examiner only

10. Many essential industrial processes, like the production of ammonia, are reversible reactions.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92.4\,\text{kJ mol}^{-1}$$

The yield for such reactions is lower than desirable because a dynamic equilibrium is reached.

(a) Give the meaning of the term dynamic equilibrium. [1]

....

....

Examiner only

(b) Use Le Chatelier's principle to explain the ideal temperature and pressure conditions needed to produce the maximum yield of ammonia. Explain why these conditions need to be adapted to achieve the optimum yield in the industrial process.

Recall of the specific conditions for the process is not required. [6 QER]

Examiner only

(c) Ammonia is converted to nitric acid in a multi-step process. The first stage involves the oxidation of ammonia to produce a mixture of nitrogen monoxide and water.

(i) Balance the equation for this reaction. [1]

$$\ldots\ NH_3 + \ldots\ O_2 \longrightarrow \ldots\ NO + \ldots\ H_2O$$

(ii) Under certain conditions an 80% conversion of ammonia to nitrogen monoxide is possible.

Calculate the minimum mass of ammonia required to produce 12 000 tonnes of nitrogen monoxide. [2]

Mass of ammonia = ... tonnes

(iii) Nitric acid is a strong acid. Calculate the pH of 500 cm^3 of an aqueous solution of nitric acid containing 2.05×10^{23} hydrogen ions. [3]

pH = ...

Examiner only

(iv) Ammonium nitrate is easily dissolved in water to produce ammonium ions (NH_4^+) and nitrate ions. A solution of ammonium ions behaves as a weak acid.

I. Give the meaning of the term acid. [1]

....

....

II. Suggest an equation to show the action of an ammonium ion as a weak acid. [1]

....

15

Examiner only

11. (a) Write a general equation for the thermal decomposition of a Group 2 metal carbonate, using M to represent the metal. [1]

....

(b) State the trend in ease of decomposition for Group 2 metal carbonates down the group. [1]

....

(c) 0.490 g of an unknown Group 2 metal carbonate decomposed completely at 790 °C and 1 atm. 425 cm^3 of carbon dioxide gas was produced.

Use the data to calculate the relative formula mass (M_r) of the metal carbonate and hence deduce the identity of the metal. [4]

M_r = ...

Metal ....

Examiner only

(d) A student was investigating the thermal decomposition of another metal carbonate. They decided that they would heat the metal carbonate until it had all decomposed and then find the loss in mass.

(i) Suggest how the student confirmed that all of the metal carbonate had decomposed. [1]

....

....

(ii) The student carried out the experiment and weighed by difference using a 2 decimal place balance. They determined the loss in mass to be 0.47 g.

Calculate the percentage error in their mass. [1]

Percentage error = ... %

8

Turn over.

Examiner only

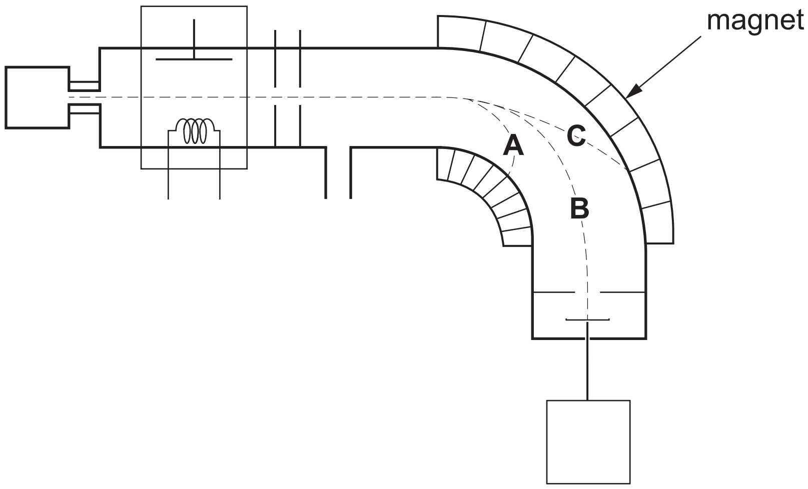
12. Mass spectrometry can be used to investigate the isotopes of elements and enables accurate relative atomic mass values to be calculated.

(a) Give the meaning of the term relative atomic mass. [2]

....

....

(b) The diagram shows one type of mass spectrometer and the paths of three particles, **A**, **B** and **C**.



(i) State the purpose of the magnet. [1]

....

....

(ii) **B** and **C** are particles of two different elements.

State why particle **C** is not detected. [1]

....

....

(iii) Particles **A** and **B** are of identical mass.

Suggest why particle **A** has been deflected far more than particle **B**. [1]

....

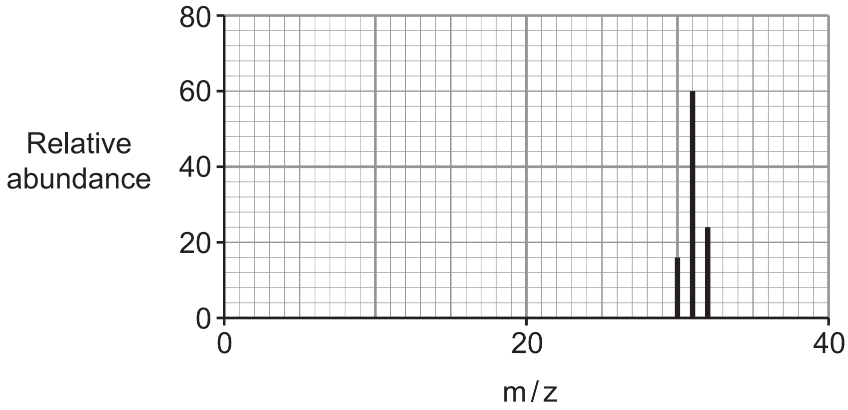
....

Examiner only

(c) The mass spectrum below was obtained from an artificial sample of an unknown element.

Use the spectrum to calculate the relative atomic mass for this sample of the element.

You **must** show your working. [2]



A_r = ...

(d) Technetium is the lightest element whose isotopes are all radioactive. Technetium-99 is a short-lived gamma-emitting isotope. It is used in nuclear medicine for a wide variety of tests such as bone cancer diagnoses.

(i) Suggest a reason why gamma-emitting isotopes are suitable for such tests but alpha-emitting isotopes are not. [1]

....

....

(ii) In certain circumstances, technetium-99 is used as a source of beta particles.

Write an equation for this emission. [2]

....

10

END OF PAPER

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

Examiner only

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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TUESDAY, 16 MAY 2023 – MORNING

CHEMISTRY – AS component 1
Data Booklet

Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
molar gas constant	R	=	8.31 J mol^{-1} K^{-1}
molar gas volume at 273 K and 1 atm	V_m	=	22.4 dm^3 mol^{-1}
molar gas volume at 298 K and 1 atm	V_m	=	24.5 dm^3 mol^{-1}
Planck constant	h	=	6.63×10^{-34} J s
speed of light	c	=	3.00×10^{8} m s^{-1}
density of water	d	=	1.00 g cm^{-3}
specific heat capacity of water	c	=	4.18 J g^{-1} K^{-1}
ionic product of water at 298 K	K_w	=	1.00×10^{-14} mol^2 dm^{-6}
fundamental electronic charge	e	=	1.60×10^{-19} C

temperature (K) = temperature (°C) + 273

1 dm^3 = 1000 cm^3
1 m^3 = 1000 dm^3
1 tonne = 1000 kg
1 atm = 1.01×10^5 Pa

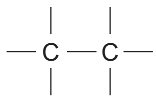
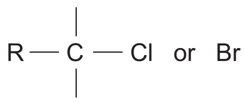
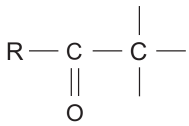
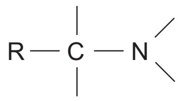
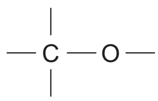
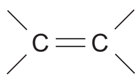
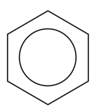
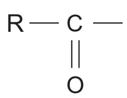
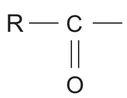
Multiple	Prefix	Symbol
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m

Multiple	Prefix	Symbol
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G

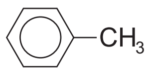
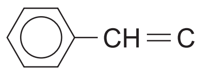
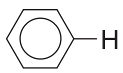
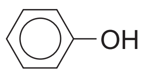
Infrared absorption values

Bond	Wavenumber / cm^{-1}
C—Br	500 to 600
C—Cl	650 to 800
C—O	1000 to 1300
C=C	1620 to 1670
C=O	1650 to 1750
C≡N	2100 to 2250
C—H	2800 to 3100
O—H (carboxylic acid)	2500 to 3200 (very broad)
O—H (alcohol / phenol)	3200 to 3550 (broad)
N—H	3300 to 3500

^{13}C NMR chemical shifts relative to TMS = 0

Type of carbon	Chemical shift, δ (ppm)
	5 to 40
	10 to 70
	20 to 50
	25 to 60
	50 to 90
	90 to 150
R—C≡N	110 to 125
	110 to 160
 (carboxylic acid / ester)	160 to 185
 (aldehyde / ketone)	190 to 220

^{1}H NMR chemical shifts relative to TMS = 0

Type of proton	Chemical shift, δ (ppm)
$—CH_3$	0.1 to 2.0
$R—CH_3$	0.9
$R—CH_2—R$	1.3
$CH_3—C \equiv N$	2.0
$CH_3—C(=O)—$	2.0 to 2.5
$—CH_2—C(=O)—$	2.0 to 3.0
	2.2 to 2.3
HC—Cl or HC—Br	3.1 to 4.3
HC—O	3.3 to 4.3
R—OH	4.5 *
—C=CH	4.5 to 6.3
—C=CH—CO	5.8 to 6.5
	6.5 to 7.5
	6.5 to 8.0
	7.0 *
$R—C(=O)—H$	9.8 *
$R—C(=O)—OH$	11.0 *

*variable figure dependent on concentration and solvent

THE PERIODIC TABLE

Key: A_r (relative atomic mass) / Symbol / Name / Z (atomic number)

s block: Groups 1–2; d block; p block: Groups 3–0; f block

Period	1	2											3	4	5	6	7	0
1	1.01 H Hydrogen 1																	4.00 He Helium 2
2	6.94 Li Lithium 3	9.01 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
3	23.0 Na Sodium 11	24.3 Mg Magnesium 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	40.0 Ar Argon 18
4	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
5	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	98.9 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
6	133 Cs Caesium 55	137 Ba Barium 56	139 La ▸ Lanthanum 57	179 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
7	(223) Fr Francium 87	(226) Ra Radium 88	(227) Ac ▸▸ Actinium 89															

f block

▸ Lanthanoid elements	140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	(147) Pm Promethium 61	150 Sm Samarium 62	(153) 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
▸▸ Actinoid elements	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