Surname	Centre Number	Candidate Number
First name(s)		2

GCE AS

B410U10-1

Z22-B410U10-1

eduqas
Part of WJEC

TUESDAY, 17 MAY 2022 – 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.**	**8**	
	8.	**16**	
	9.	**16**	
	10.	**13**	
	11.	**17**	
	Total	**80**	

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.

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (70 marks)**.

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.9**(a).

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SECTION A

Answer **all** questions.

1. (a) State what is meant by a **polar** covalent bond. [1]

....

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

H — F

2. Iodine-131 decays by beta emission.

Identify the element formed. [1]

....

3. A mass of 2.750 g is weighed by difference.

Calculate the percentage error in this value when a 3 decimal place balance is used. [2]

Percentage error = ... %

4. Complete the electron arrangement of iron. [1]

$1s^2\ 2s^2\ 2p^6$ ....

5. Write an equation for the thermal decomposition of calcium hydroxide. [1]

....

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6. (a) State why magnesium and barium are described as *s*-block elements. [1]

....

....

(b) Describe how the results of a flame test would differentiate between samples of magnesium sulfate and barium sulfate. [1]

....

....

(c) Barium sulfate can be made using a precipitation reaction between solutions of two metal compounds. One of the compounds is barium chloride.

Identify a metal compound that could be used for the other solution. [1]

....

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10

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SECTION B

Answer **all** questions.

7. When heated above 100 °C, nitrosyl chloride (NOCl) partially decomposes to form nitrogen monoxide and chlorine.

$$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$$

(a) Write an expression for the equilibrium constant (K_c) for this reaction.

Give the unit of K_c. [2]

Unit ....

(b) At a fixed temperature, a mixture of NOCl, NO and Cl_2 reached equilibrium in a sealed container.

The equilibrium mixture formed contained NOCl, at a concentration of 0.126 mol dm^{-3}, and NO, at a concentration of 5.73×10^{-2} mol dm^{-3}.

The value of K_c for the equilibrium at this temperature was 7.40×10^{-3}.

Calculate the concentration of Cl_2 in this equilibrium mixture. [3]

Concentration of Cl_2 = ... mol dm^{-3}

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(c) State and explain, with reference to Le Chatelier's principle, how the amount of chlorine would change if the reaction were carried out at a higher pressure. [3]

....

....

....

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....

8

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8. Xenon is found in Group 0 of the Periodic Table.

(a) Xenon has a first ionisation energy of 1170 kJ mol^{-1}.

(i) Explain why the first ionisation energy of xenon is lower than that of krypton. [2]

....

....

....

....

(ii) Explain why the first ionisation energy of xenon is higher than that of iodine. [2]

....

....

....

....

(b) Xenon is an unreactive element but can be made to react with the very electronegative element fluorine.

(i) State the meaning of the term electronegativity. [1]

....

....

(ii) Xenon difluoride is one of the most stable xenon compounds. It is a white solid with a melting temperature of 128.6 °C.

Suggest the type of solid structure present in xenon difluoride. [1]

....

(iii) Write an equation for the reaction of xenon with fluorine to make xenon difluoride. [1]

....

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(iv) Calculate the volume of xenon gas required, at a temperature of 400 °C and a pressure of 1.00×10^5 Pa, to make 5.00 g of xenon difluoride.

Give your answer in dm^3. [3]

Volume of xenon = ... dm^3

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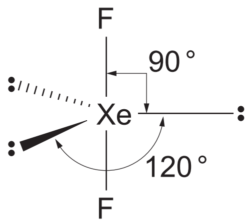
(v) Xenon difluoride molecules are linear.



Using your knowledge and understanding of VSEPR theory, suggest why the electron pairs arrange themselves in this way. [2]

....

....

....

....

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Turn over.

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(vi) Xenon difluoride is a strong oxidising agent.

An example of such a reaction is given below.

$$2CrO_2F_2 \quad + \quad XeF_2 \longrightarrow 2CrOF_3 \quad + \quad Xe \quad + \quad O_2$$

Use the oxidation states of xenon and oxygen to show why xenon difluoride is an oxidising agent in this reaction. [2]

....

....

....

....

(vii) Xenon difluoride reacts with water to produce hydrogen fluoride and two elements.

Write an equation to represent this reaction. [2]

....

16

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9. Water authorities provide millions of customers with a safe and reliable water supply. To do this they operate a comprehensive monitoring system.

(a) Mass spectrometry is just one of the many techniques that can be used to analyse water samples. Both chlorine and chlorine-containing compounds can be analysed in this way.

Outline how the mass spectrometer works and describe the mass spectrum of chlorine. [6 QER]

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(b) There are regulations to govern limits of certain chemicals in drinking water.

Species	Level not to be exceeded
arsenic	10 μg/l
copper	2 mg/l
chromium	50 mg/l
fluoride	1.5 mg/l

(i) The volume of water needed to fill a glass is 330 cm^3.

Calculate the mass of the water in the glass. [1]

Mass = ... g

(ii) Calculate the number of hydrogen atoms present in this mass of water. [2]

Number of hydrogen atoms = ...

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(iii) A student has two different water samples contained in glasses identical to the one in (b)(i).

One sample is a full glass containing water contaminated with arsenic and the other sample is a glass one-third full, containing water contaminated with copper.

Given that both these water samples contain the maximum mass of these contaminants, according to the limits in the table, determine which sample contains the greater number of moles of contaminant.

You **must** show your working. [3]

....

....

(c) Some water authorities add calcium fluoride to their drinking water and other water authorities do not.

Explain your own view on the fluoridation of drinking water, including arguments for and against. [3]

....

....

....

....

....

....

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(d) Water from the Peak District has percolated through rocks containing calcium fluoride in the form of the mineral fluorspar.

Calcium fluoride, CaF_2, has a solubility of 1.7×10^{-3} g / 100 g of water.

Calculate the number of moles of calcium fluoride dissolved in 100 g of this water. [1]

Number of moles = ... mol

16

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10. Gallium is an unusual metal because it melts if you hold it in your hand. It has a melting temperature of 29.8 °C.

(a) Aluminium is above gallium in the Periodic Table. It melts at 660 °C.

Describe the solid structure of aluminium using a labelled diagram to support your answer. [3]

....

....

....

....

(b) In gallium the bonding between two neighbouring particles is covalent and the structure is built up from Ga_2 dimers, similar to the structure of iodine.

Use this information to explain the unusual melting temperature of gallium compared to aluminium. [3]

....

....

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(c) Gallium has 31 known isotopes but only two of them are stable and occur naturally – gallium-69 and gallium-71.

Given that the relative atomic mass of natural gallium is 69.798, determine the percentage abundance of these two isotopes. [3]

Abundance of Ga-69 = ... %

Abundance of Ga-71 = ... %

(d) (i) Write an equation for the first ionisation energy of gallium. [1]

....

(ii) Ionisation energy can be measured in electron volts where

$$1\,\text{eV} = 1.602 \times 10^{-19}\,\text{J}$$

The first ionisation energy of gallium has a value of 5.9993 eV.

Calculate the wavelength of radiation, in m, that will ionise an atom of gallium to form a Ga^{+} ion. [3]

Wavelength = ... m

13

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11. (a) In a titration experiment, good technique is essential for an accurate result to be obtained.

(i) Suggest a reason for removing the funnel after it has been used for filling the burette. [1]

....

....

(ii) Suggest **one** other potential source of error in **using** the burette to carry out a titration. [1]

....

....

(b) Sodium hydroxide solutions are often contaminated with sodium carbonate owing to the ease with which sodium hydroxide reacts with carbon dioxide in the air.

The technique of double titration allows us to determine the extent to which a solution has been contaminated.

(i) Write an equation for the reaction between sodium hydroxide and carbon dioxide. [1]

....

(ii) The method of double titration uses two indicators to determine two end-points. During the titration, hydroxide ions and carbonate ions react according to the following equations.

hydroxide: $OH^- + H^+ \longrightarrow H_2O$

carbonate: $CO_3^{2-} + H^+ \longrightarrow HCO_3^-$

} both complete at phenolphthalein stage

$HCO_3^- + H^+ \longrightarrow CO_2 + H_2O$ complete at methyl orange stage

By recording the volumes of hydrochloric acid added at each end-point it is possible to calculate the concentrations of the hydroxide ions and carbonate ions in the original solution and thus determine the extent of contamination.

Assume that hydroxide ions and carbonate ions are the only anions in the initial solution.

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A 1.00 dm^3 flask containing sodium hydroxide solution had been left open to the air in a laboratory for a period of time.

A student performed a double titration to determine the volume of carbon dioxide that had reacted with the sodium hydroxide solution.

He titrated a 25.0 cm^3 sample of the solution with 1.00 $mol\,dm^{-3}$ hydrochloric acid. He recorded the volume used at the phenolphthalein end-point.

He then added methyl orange and continued titrating to its end-point and recorded the total volume of hydrochloric acid added.

Results

Volume of HCl at the phenolphthalein end-point / cm^3	22.50
Total volume of HCl added at the methyl orange end-point / cm^3	25.00

I. Calculate the number of moles of hydrochloric acid used in the first stage of the titration. This gives the total number of moles of hydroxide ions plus carbonate ions in the 25.0 cm^3 sample. [1]

Number of moles = ... mol

II. Calculate the number of moles of hydrogencarbonate ions reacting in the second stage of the reaction. [2]

Number of moles = ... mol

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III. Using your answers from parts I. and II., determine the number of moles of carbonate ions and hence the number of moles of hydroxide ions in the $25.0\,cm^3$ sample. [2]

Number of moles of carbonate ions = ... mol

Number of moles of hydroxide ions = ... mol

IV. Using the number of moles of carbonate ions determined in part III., calculate the volume of carbon dioxide absorbed into the original solution at 298 K and 1 atm. [3]

Volume of carbon dioxide = ... dm^3

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(c) (i) Explain what is meant by a **strong** acid and write an equation to show how hydrochloric acid behaves as a strong acid. [2]

....

....

....

(ii) I. Calculate the pH of 500 cm^3 of 0.50 mol dm^{-3} hydrochloric acid. [1]

pH = ...

II. Calculate the volume of water that must be added to this solution to increase its pH to a value of 1.0.

Show your working. [3]

Volume of water added = ... dm^3

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END OF PAPER

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

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TUESDAY, 17 MAY 2022 – 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

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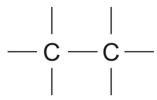
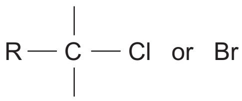
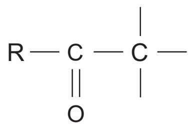
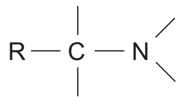
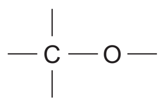
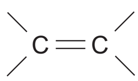
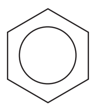
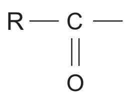
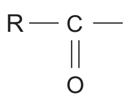
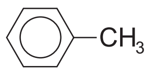
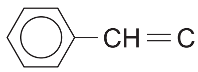
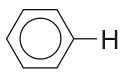
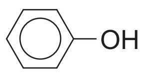
Infrared absorption values

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
	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 and 2. d block: the 10 unnumbered columns between Group 2 and Group 3. p block: Groups 3 to 0.

Period	Group 1	Group 2											Group 3	Group 4	Group 5	Group 6	Group 7	Group 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