OCR
RECOGNISING ACHIEVEMENT

SPECIMEN

Advanced Subsidiary GCE

CHEMISTRY A

Unit F321: Atoms, Bonds and Groups

Specimen Paper

F321 QP

Candidates answer on the question paper.

Additional Materials:
Data Sheet for Chemistry (Inserted)
Scientific calculator

Time: 1 hour

Candidate Name	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry* is provided as an insert with this question paper.
- You are advised to show all the steps in any calculations.
- The total number of marks for this paper is **60**.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	**12**	
2	**12**	
3	**12**	
4	**12**	
5	**12**	
TOTAL	**60**	

This document consists of **11** printed pages, **1** blank page and a *Data Sheet for Chemistry*.

  [Turn Over

Answer **all** the questions.

1 The Group 7 element bromine was discovered by Balard in 1826. Bromine gets its name from the Greek *bromos* meaning stench.

(a) Bromine consists of a mixture of two isotopes, ^{79}Br and ^{81}Br.

(i) What is meant by the term *isotopes*?

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..... **[1]**

(ii) Complete the table below to show the atomic structures of the bromine isotopes.

	protons	**neutrons**	**electrons**
^{79}Br			
^{81}Br			

[2]

(iii) Write the full electronic configuration of a bromine atom.

$1s^2$..... **[1]**

(b) A student added an aqueous solution of sodium iodide to a solution of bromine.

The colour turned from orange to a deep brown.

The student then added an aqueous solution of sodium chloride to a solution of bromine.

The orange colour was unchanged.

(i) Explain these observations.

In your answer, you should use appropriate technical terms, spelled correctly.

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..... **[3]**

(ii) Write an ionic equation for the reaction that has taken place.

..... **[1]**

(c) A student read about possible health problems arising from the use of common salt added to different foods. The student decided to compare the salt content of different foods using simple test-tube tests to test the chloride content.

Plan a simple qualitative experiment to compare the quantity of chloride ions in different foods. Comment on the validity of claiming that the chloride content is the same as the salt content.

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..... **[4]**

[Total: 12]

[Turn over

2 This question refers to the elements in the first four periods of the Periodic Table.

							H										He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr

(a) Identify an element from the first four periods that fits each of the following descriptions.

(i) The element that forms a 2– ion with the same electronic configuration as Ar.

..... **[1]**

(ii) The element that forms a 3+ ion with ten electrons.

..... **[1]**

(iii) An element that forms a compound with fluorine with trigonal planar molecules.

..... **[1]**

(iv) The element that forms a chloride XCl_2 with a molar mass of 111.1 g mol^{-1}.

..... **[1]**

(v) The element with the largest atomic radius.

..... **[1]**

(vi) The element with the smallest first ionisation energy.

..... **[1]**

(b) Ionisation energies provide information about the model for the electron structure of elements.

(i) Explain why first ionisation energies show a general increase across Period 3, Na–Ar.

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..... **[3]**

(ii) Write an equation, including state symbols, to represent the third ionisation energy of sodium.

..... **[1]**

(iii) Element **X** is in Period 3 of the Periodic Table, Na–Ar.

The first six ionisation energies of an element **X** are shown below.

ionisation number	1st	2nd	3rd	4th	5th	6th
ionisation energy /kJ mol^{-1}	789	1577	3232	4 556	16091	19 785

Predict, with reasons, the identity of element **X**.

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..... **[2]**

[Total: 12]

[Turn over

3 Chemists have developed models for bonding and structure. These models are used to explain different properties of metals and non-metals.

(a) **(i)** Draw a labelled diagram to show the currently accepted model for *metallic bonding*.

[2]

(ii) What feature of this model allows metals to conduct electricity?

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..... **[1]**

(b) The metal magnesium reacts with the non-metal chlorine to form a compound magnesium chloride, $MgCl_2$, which has ionic bonding.

(i) State what is meant by an *ionic bond*.

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..... **[1]**

(ii) '*Dot-and-cross*' diagrams are used to model which electrons are present in the ion.

Draw a '*dot-and-cross*' diagram, including outer electron shells only, to show the ions present in magnesium chloride, $MgCl_2$.

[2]

(iii) A student finds that solid magnesium chloride and pure water do not conduct electricity. The student dissolved the magnesium chloride in the water and the resulting solution **does** conduct electricity.

Explain these observations.

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..... **[3]**

(c) The non-metals chlorine and carbon have very different boiling points. Chlorine is a gas at room temperature but carbon does not boil until well over 4500 °C.

Explain this difference, in terms of bonding and structure.

In your answer, you should use appropriate technical terms, spelled correctly.

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..... **[3]**

[Total: 12]

4 Calcium and its compounds, have properties typical of Group 2 in the Periodic Table.

(a) Calcium carbonate, $CaCO_3$, reacts with acids such as nitric acid.

A student neutralised 2.68 g of $CaCO_3$ with 2.50 mol dm^{-3} nitric acid, HNO_3.

The equation for this reaction is shown below.

$$CaCO_3(s) + 2HNO_3(aq) \longrightarrow Ca(NO_3)_2(aq) + CO_2(g) + H_2O(l)$$

(i) Determine the amount, in mol, of $CaCO_3$ reacted.

amount = ... mol **[2]**

(ii) Calculate the volume, in cm^3, of CO_2 produced at room temperature and pressure.

volume = ... cm^3 **[1]**

(iii) Calculate the volume of 2.50 mol dm^{-3} HNO_3 needed to neutralise 2.68 g of $CaCO_3$.

volume = ... cm^3 **[2]**

(b) The student left the solution of calcium nitrate formed in **(a)** to crystallise. Crystals of hydrated calcium nitrate formed containing 30.50% of H_2O, by mass.

Calculate the formula of the hydrated calcium nitrate.

[3]

(c) A student prepared an aqueous solution of calcium chloride by reacting calcium with hydrochloric acid.

$$Ca(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2(g)$$

(i) Using oxidation numbers, show that this is a redox reaction.

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..... **[2]**

(ii) The student had added the exact amount of calcium required to react with the hydrochloric acid used. After carrying out the experiment, the student accidentally added some more calcium. The student was surprised that the extra calcium still reacted.

Explain this observation. Include an equation in your answer.

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..... **[2]**

[Total: 12]

[Turn over

5 Water, ammonia and sulfur dioxide are simple molecular compounds.

(a) Pairs of electrons in molecules may be present as *bonding pairs* or as *lone pairs*.

(i) Complete the table below for water, ammonia and sulfur dioxide.

molecule	H_2O	NH_3	SO_2
number of bonding pairs of electrons			4 (two double bonds)
number of lone pairs of electrons around central atom			1

[2]

(ii) Use your answers to **a(i)** to help you draw the shape of, and bond angle in, a molecule of NH_3 and of SO_2.

molecule	NH_3	SO_2
shape of molecule with bond angles		

[4]

(b) Water forms hydrogen bonds which influences its properties.

Explain, with a diagram, what is meant by *hydrogen bonding* and explain **two** anomalous properties of water resulting from hydrogen bonding.

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..... **[6]**

[Total: 12]

Paper Total [60]

END OF QUESTION PAPER

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OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

CHEMISTRY A F321

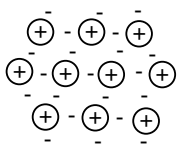
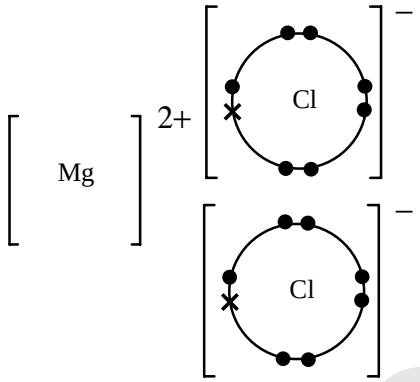
Unit F321: Atoms, Bonds and Groups

Specimen Mark Scheme

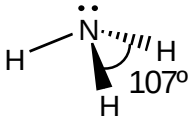
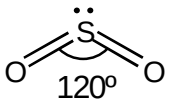
The maximum mark for this paper is **60**.

This document consists of **6** printed pages and **2** blank pages.

Question Number	Answer	Max Mark
1(a)(i)	atoms of the same element with different numbers of neutrons/different masses ✓	[1]
(ii)	^{79}Br 35 protons, 44 neutrons, 35 electrons ✓ ^{81}Br 35 protons, 46 neutrons, 35 electrons ✓	[2]
(iii)	$(1s^2)2s^22p^63s^23p^63d^{10}4s^24p^5$✓	[1]
(b)(i)	iodide has been converted to iodine ✓ (with correct use and spelling of iodide and iodine) The 1st experiment shows that bromine is more reactive than iodine ✓ The 2nd experiment shows that chlorine is more reactive than bromine ✓ *Accept 1 mark for 2nd and 3rd marking points if the correct reactivity order of chlorine > bromine > iodine has been stated.*	[3]
(ii)	$Br_2 + 2I^- \longrightarrow 2Br^- + I_2$ ✓	[1]
(c)	add $AgNO_3/Ag^+$ (to a solution of the food) ✓ $Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$ ✓ degree of cloudiness/whiteness/intensity indicates relative quantity ✓ sodium **ion** content needs to be determined as well ✓	[4]
2(a)(i)	S ✓	[1]
(ii)	Al ✓	[1]
(iii)	B ✓	[1]
(iv)	Ca ✓	[1]
(v)	K ✓	[1]
(vi)	K ✓	[1]
(b)(i)	atomic radii decrease /similar shielding /electrons added to same shell ✓ number of protons in the nucleus increases ✓ nuclear attraction increases ✓	[3]
(b)(ii)	$Na^{2+}(g) \longrightarrow Na^{3+}(g) + e^-$: equation **and** state symbols ✓	[1]
(b)(iii)	large jump (in energy) between the 4th and 5th ionisation energies ✓ four electrons in outer shell so element is Si ✓	[2]

Question Number	Answer	Max Mark
3(a)(i)	 positive ions ✓electrons ✓ (must be labelled)	[2]
(ii)	the electrons move ✓	[1]
(b)(i)	attraction between oppositely charged ions ✓	[1]
(ii)	 Mg and Cl both with 8 electrons in outer shell, (accept 0 electrons for Mg) Cl must have one dot to seven crosses or vice versa ✓ correct charges on each ion✓	[2]
(iii)	$MgCl_2$ does not conduct when solid because ions are fixed in lattice✓ H_2O does not conduct as there are no free charge carriers/water molecules are uncharged ✓ $MgCl_2$ conducts when aqueous because ions are free to move ✓	[3]
(c)	To boil Cl_2, van der Waals' forces/intermolecular forces are broken (with van der Waals/intermolecular spelt correctly)✓ To boil C, covalent bonds are broken ✓ covalent bonds are stronger than van der Waals' forces ✓	[3]

Question Number	Answer	Max Mark
4(a)(i)	Molar mass of $CaCO_3$ = 100.1 g mol^{-1} ✓ 2.68/100.1 = 0.0268/0.027 ✓	**[2]**
(ii)	0.0268 mol x 24,000 = 643 cm^3 ✓	**[1]**
(iii)	moles HNO_3 = 2 x 0.0268 = 0.0536 /0.054 mol ✓ *(i.e. answer to (i) x 2)* volume of HNO_3 = 0.0536 x 1000/2.50 = 21.4 cm^3 ✓	**[2]**
(b)	Molar mass of anhydrous calcium nitrate = 164.1 g mol^{-1} ✓ Ratio $Ca(NO_3)_2$: H_2O = 69.50/164.1 : 30.50/18 or 0.4235 : 1.694 or 1 : 4 ✓ Formula = $Ca(NO_3)_2 \bullet 4H_2O$ ✓	**[3]**
(c)(i)	because Ca has changed from 0 to +2 ✓ and H has changed from +1 to 0 ✓	**[2]**
(ii)	Calcium reacts with water producing hydrogen/H_2/calcium/hydroxide/$Ca(OH)_2$ ✓ (i.e. one product) $Ca(s) + H_2O(l) \longrightarrow Ca(OH)_2(aq) + H_2(g)$ ✓ (i.e. full equation) Equation would subsume both two marks	**[2]**

Question Number	Answer	Max Mark
5(a)(i)	H_2O NH_3 2 3 ✓ 2 1 ✓	**[2]**
(ii)	 shape ✓ bond angle labelled on diagram as 107 ° ✓  shape ✓ bond angle labelled on diagram as 110–120° ✓	**[4]**
(b)	H bonding from lone pair on O of 1 H_2O molecule to H of another ✓ dipoles shown ✓ Two properties: Ice is lighter than water/ max density at 4°C ✓ explanation: H bonds hold H_2O molecules apart / open lattice in ice / H-bonds are longer ✓ Higher melting/boiling point than expected ✓ explanation: strength of H bonds that need to be broken ✓ *must imply that intermolecular bonds are broken* High surface tension/viscosity ✓ explanation:strength of H bonds across surface ✓	**[6]**
	Paper Total	**[60]**

Assessment Objectives Grid (includes QWC)

Question	AO1	AO2	AO3	Total
1(a)(i)	1			**1**
1(a)(ii)	2			**2**
1(a)(iii)		1		**1**
1(b)(i)		3		**3**
1(b)(ii)	1			**1**
1(c)			4	**4**
2(a)(i)		1		**1**
2(a)(ii)		1		**1**
2(a)(iii)	1			**1**
2(a)(iv)		1		**1**
2(a)(v)	1			**1**
2(a)(vi)	1			**1**
2(b)(i)	3			**3**
2(b)(ii)	1			**1**
2(b)(iii)		2		**2**
3(a)(i)	2			**2**
3(a)(ii)	1			**1**
3(b)(i)	1			**1**
3(b)(ii)		2		**2**
3(b)(iii)		3		**3**
3(c)	3			**3**
4(a)(i)		2		**2**
4(a)(ii)		1		**1**
4(a)(iii)		2		**2**
4(b)		3		**3**
4(c)(i)		2		**2**
4(c)(ii)		2		**2**
5(a)(i)	2			**2**
5(a)(ii)	2	2		**4**
5(b)	6			**6**
Totals	**28**	**28**	**4**	**60**

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