OCR A-LEVEL CHEMISTRY A

CHEMISTRY



EXAM QUESTION PACK

UNIT F321 OLD SPECIFICATION PAPERS

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OCR
Oxford Cambridge and RSA

Friday 27 May 2016 – Morning

AS GCE CHEMISTRY A

F321/01 Atoms, Bonds and Groups

Candidates answer on the Question Paper.

OCR supplied materials:
- *Data Sheet for Chemistry A* (inserted)

Other materials required:
- Scientific calculator

Duration: 1 hour

F 3 2 1 0 1

5986785801

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The Insert will be found inside this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional answer space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry A* 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**.
- This document consists of **16** pages. Any blank pages are indicated.

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Answer **all** the questions.

1 Nitrogen is the most common gas in the atmosphere.

(a) Atoms of nitrogen consist of protons, neutrons and electrons.

Complete the table below.

Particle	Relative mass	Relative charge	Position within the atom
Proton			
Neutron			
Electron			shell

[2]

(b) The electrons in the second shell of a nitrogen atom are found in an s-orbital and three p-orbitals.

(i) State, in words, the 3D shape of an s-orbital and a p-orbital.

s-orbital .....

p-orbital .....

[1]

(ii) Describe the relative energies of the 2s orbital and **each** of the three 2p orbitals in a nitrogen atom.

.....

.....

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

(c) Draw a '*dot-and-cross*' diagram to show the bonding in a nitrogen molecule.

Show **outer** electrons only.

[1]

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(d) Calculate the amount, in mol, of nitrogen **atoms** in 5.117×10^{20} nitrogen **molecules**.

Give your answer in standard form.

amount of nitrogen atoms = ... mol **[2]**

(e) N_2O_3 is an unstable oxide of nitrogen that decomposes in a redox reaction.

$$N_2O_3(g) \longrightarrow NO(g) + NO_2(g)$$

(i) State the oxidation number of nitrogen in each oxide in the table below.

Oxide	Oxidation number of nitrogen
N_2O_3	
NO	
NO_2	

[1]

(ii) Name this type of redox reaction.

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

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

(f) N_2O_3 reacts with water to form an acid as the only product. This reaction is **not** a redox reaction. The empirical formula of the acid formed is the same as the molecular formula.

(i) State what is meant by the term *molecular formula*.

.....

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

(ii) Suggest the empirical formula of the acid formed.

empirical formula of acid = ... **[1]**

[Total: 12]

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2 This question is about halogens.

(a) Solid chlorine and solid bromine have a similar structure.

Name this structure.

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

(b) The intermolecular attractions in halogens are van der Waals' forces.

(i) Explain how van der Waals' forces arise between halogen molecules.

.....

.....

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

(ii) The boiling points of chlorine and bromine are shown in the table.

Halogen	**Boiling point / °C**
chlorine	–34
bromine	59

Explain why bromine has a higher boiling point than chlorine.

.....

.....

.....

.....

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

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(c) A student carries out test-tube experiments to prove the trend in reactivity of halogens.

The student is provided with the following solutions:

- bromine water
- aqueous iodine
- aqueous barium chloride
- aqueous magnesium bromide
- aqueous calcium iodide.

Chlorine gas and chlorine water are **not** available.

The student carries out the **minimum** number of test-tube experiments using these solutions in the presence of cyclohexane (an organic solvent).

- State the solutions that need to be added together in order to prove the trend in reactivity of the halogens, using the **minimum** number of test-tube experiments.

- Describe the colour seen in the organic solvent at the end of each test-tube experiment.

- Write an ionic equation for **one** reaction that takes place.

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..... **[5]**

[Total: 11]

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3 The elements of Period 2 and Period 3 of the Periodic Table are shown in **Table 3.1**.

Group	1	2	3	4	5	6	7	0
Period 2	Li	Be	B	C	N	O	F	Ne
Period 3	Na	Mg	A*l*	Si	P	S	C*l*	Ar

Table 3.1

(a) The elements in these two periods show a repeating pattern in chemical and physical properties.

What is the name given to this repeating pattern of properties?

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

(b) State the element in **Table 3.1** with:

- the lowest first ionisation energy .....
- the lowest fourth ionisation energy .....
- the lowest boiling point .....

[3]

(c) Gallium, atomic number 31, is in Period 4 of the Periodic Table. Gallium is a Group 3 element.

Predict the formula of a gallium ion.

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

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(d) The melting points of the Period 3 metals sodium and magnesium are shown below.

Metal	Melting point / °C
sodium	98
magnesium	649

Explain the differences in the melting points of sodium and magnesium, using the model of metallic bonding.

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

.....

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

(e) When magnesium nitrate, $Mg(NO_3)_2$, is heated, it decomposes as shown.

$$2Mg(NO_3)_2(s) \rightarrow 2MgO(s) + 4NO_2(g) + O_2(g)$$

A student heats 2.966 g of $Mg(NO_3)_2$, which decomposes as above.

Calculate the **total** volume of gas formed, in cm^3, at room temperature and pressure, RTP.

total volume of gas formed = ... cm^3 **[3]**

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(f) Fluorine forms several compounds with sulfur and with oxygen.

(i) Give the **formula** and the **name** of the compound formed between fluorine and sulfur which has octahedral molecules.

Formula .....

Name .....

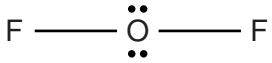
[1]

(ii) Fluorine reacts with aqueous sodium hydroxide to form the oxide F_2O.
Two other products are also formed. One product is an ionic compound with a relative formula mass of 42.0.

Construct a balanced equation for this reaction.

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

(g) **(i)** Fluorine is the most electronegative element.
Indicate any dipoles on the molecule of F_2O below using partial charges.



[1]

(ii) Suggest the **shape** of the F_2O molecule and the F–O–F **bond angle**.

Shape .....

Bond angle .....

[1]

(iii) What is the oxidation number of oxygen in F_2O?

Include the sign in your answer.

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

[Total: 17]

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PLEASE DO NOT WRITE ON THIS PAGE

Turn over for the next question

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4 This question is about the chemistry of the metals zinc, magnesium, aluminium and calcium.

(a) Complete the electron configuration of a zinc atom.

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

(b) A sample of zinc was found to contain four isotopes with the abundances shown in the table.

Isotope	Abundance (%)
^{64}Zn	49.0
^{66}Zn	27.9
^{67}Zn	4.3
^{68}Zn	18.8

(i) Define the term *relative atomic mass*.

.....

.....

.....

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

(ii) Calculate the relative atomic mass of zinc in this sample.

Give your answer to **two** decimal places.

relative atomic mass of zinc = ... **[2]**

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(c) Zinc carbonate, $ZnCO_3$, reacts with dilute hydrochloric acid.

A student reacts a sample of $ZnCO_3$ with an excess of dilute hydrochloric acid in a test-tube.

(i) Describe what the student would see during this reaction.

.....

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

(ii) Write the equation for the reaction between $ZnCO_3$ and dilute hydrochloric acid.

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

(d) Magnesium will undergo redox reactions with aqueous salts of less reactive metals.

(i) A student reacts magnesium with aqueous copper(II) sulfate.

$$Mg(s) + CuSO_4(aq) \longrightarrow Cu(s) + MgSO_4(aq)$$

Explain, in terms of **numbers** of electron transferred, the redox processes taking place in this reaction.

.....

.....

.....

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

(ii) The student also noticed that the magnesium started fizzing.

The student thought the fizzing was due to the magnesium reacting with water in the mixture.

Write the equation for the reaction of magnesium with water.

Include state symbols.

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

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(e) A student reacts 35.0 cm^3 of 3.00×10^{-2} mol dm^{-3} $H_2SO_4(aq)$ with an excess of A*l*.

An equation for this reaction is shown.

$$2Al(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 3H_2(g)$$

Calculate the mass, in g, of $Al_2(SO_4)_3$ formed in solution.

Give your answer to **three** significant figures.

Show your working.

mass = ... g **[4]**

(f) Compounds of calcium have many uses.

(i) Identify a compound of calcium that could be used to convert a soil pH from 5.8 to 7.5.

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

(ii) Calcium phosphide, Ca_3P_2, is an ionic compound used in rat poison.

Calcium phosphide can be prepared by reacting calcium metal with phosphorus, P_4.

Write the equation for the reaction of calcium with phosphorus to form calcium phosphide.

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

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(iii) Draw a '*dot-and-cross*' diagram to show the bonding in calcium phosphide, Ca_3P_2.

Show **outer** electrons only.

[2]

[Total: 20]

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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GCE

Chemistry A

Unit **F321:** Atoms, Bonds and Groups

Advanced Subsidiary GCE

Mark Scheme for June 2016

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Annotations

Annotation	Meaning
BOD	Benefit of doubt given
CON	Contradiction
	Incorrect response
ECF	Error carried forward
I	Ignore
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error
SF	Error in number of significant figures
	Correct response

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Abbreviations

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

The following questions should be annotated with ticks  , crosses  , ignore  , etc to show where marks have been awarded in the body of the text

2bi
2c
3d

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<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td></td><td>
<table>
<tr><th>particle</th><th>relative mass</th><th>relative charge</th><th>position within the atom</th></tr>
<tr><td>proton</td><td>1</td><td>+ 1</td><td>nucleus</td></tr>
<tr><td>neutron</td><td>1</td><td>nil/0</td><td>nucleus</td></tr>
<tr><td>electron</td><td>1/2000</td><td>– 1</td><td>shell</td></tr>
</table>
Relative mass column ✓

Relative charge AND position columns ✓</td><td>2</td><td>For relative masses
ALLOW 1/1800 to 1/2000 for electron value (0.0005–0.00056)
ALLOW ‘negligible’ for electron value
IGNORE ‘+’ in front of correct values
DO NOT ALLOW ‘–’ in front of 1/2000
DO NOT ALLOW ‘nil’ OR ‘zero’ for mass of electron

For relative charges
ALLOW 1+ and ‘neutral’ and 1–
IGNORE ‘–‘ (ie a dash) for neutron
DO NOT ALLOW ‘+’ or ‘–‘ without ‘1’
DO NOT ALLOW ‘1’ without charge

For position within the atom
IGNORE ‘middle OR ‘centre’ for ‘nucleus’</td></tr>
<tr><td>1</td><td>(b)</td><td>(i)</td><td>s-orbital = spherical
AND
p-orbital = dumb-bell shape ✓</td><td>1</td><td>For s-orbital
IGNORE ‘circular’

For p-orbital
ALLOW other words indicating 3-D shape of p-orbital eg ‘Peanut-shaped’ OR hour glass etc
ALLOW ‘figure of eight’ OR ‘figure of 8’
IGNORE diagrams</td></tr>
<tr><td>1</td><td></td><td>(ii)</td><td>p-orbitals have greater energy than s-orbitals ✓

(three) p-orbitals have equal energy ✓</td><td>2</td><td>ALLOW reverse argument

ALLOW suitable energy diagram for either part</td></tr>
</table>

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Question			Answer	Mark	Guidance
1	(c)		 ✓	1	**ALLOW** *all* dots or *all* crosses.
1	(d)		First check the answer line. If answer = $1.7(0) \times 10^{-3}$ award 2 marks. --- M1 (Dividing by 6.02×10^{23}) Number of N_2 molecules = $\frac{5.117 \times 10^{20}}{6.02 \times 10^{23}} = 8.5. \times 10^{-4}$ **OR** 0.85×10^{-3} **OR** 0.085×10^{-2} **OR** 0.0085×10^{-1} **OR** 0.00085 ✓ M2 (Correct conversion of molecules to atoms + **standard form**) M1 x 2 **and** in standard form ✓ From 0.0085, answer = 2 x 0.00085 = 0.00170 **= $1.7(0) \times 10^{-3}$** *Alternative method* M1 (Correct conversion of molecules to atoms) $= 5.117 \times 10^{20} \times 2 = 1.02(34) \times 10^{21}$ **OR** $10.2(34) \times 10^{20}$ **OR** $102.(34) \times 10^{19}$ etc M2 (Correct use of 6.02×10^{23} + **standard form**) $\frac{1.02(34) \times 10^{21}}{6.02 \times 10^{23}}$ = **$1.7(0) \times 10^{-3}$**	2	**ALLOW** one mark for 0.17×10^{-2} **OR** 0.017×10^{-1} **OR** 0.0017 (not standard form) **ALLOW** one mark for 4.25×10^{-4} (dividing by 2 in M2 + standard form) **ALLOW** one mark for 6.16×10^{44} (multiplying by 6.02×10^{23} in M1 + standard form)

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Question			Answer	Mark	Guidance
1	(e)	(i)	N_2O_3 = +3 NO = +2 NO_2 = +4 ✓	1	**ALLOW** '3' **OR** '3+' etc **ALLOW** oxidation numbers written over the equation but **IGNORE** if oxidation numbers are given on the answer lines
		(ii)	Disproportionation ✓	1	QWC 'disproportionation' spelled correctly.
1	(f)	(i)	(Actual) number of atoms of **each element** present in a molecule ✓	1	**ALLOW** 'compound' for 'molecule' **IGNORE** 'simplest whole' before 'number' **ALLOW** 'actual ratio' **IGNORE** 'ratio' alone **DO NOT ALLOW** 'simplest ratio'
		(ii)	HNO_2 ✓	1	**ALLOW** O_2HN etc
			Total	**12**	

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Question			Answer	Mark	Guidance
2	(a)		Simple molecular lattice ✓	1	**ALLOW** 'simple covalent' **OR** 'simple molecular' ie 'simple' must be seen. **DO NOT ALLOW** 'simple covalent *bonds*'
2	(b)	(i)	M1 *Creating the dipole mark* Uneven distribution of **electrons** ✓ M2 *Type of dipole mark* This creates/causes an instantaneous dipole **OR** temporary dipole ✓ M3 *Induction of a second dipole mark* This causes an **induced dipole** on a neighbouring/adjacent molecule(s)/halogens ✓	3	**IGNORE** use of 'atoms' for M1 and M2 **ALLOW** (random) movement of **electrons** **ALLOW** change in **electron** density **ALLOW** alternative expression for instantaneous **dipole** Eg transient dipole, oscillating dipole, momentary dipole, changing dipole **DO NOT ALLOW** the induction of an instantaneous or temporary dipole for M2 **DO NOT ALLOW** the idea of a permanent dipole **OR** formation of ions for M2 **ALLOW** resultant dipole on an adjacent molecule(s) **IGNORE** atoms for molecules **IGNORE** instantaneous/temporary for M3
		(ii)	M1 *Electron mark* Bromine has **more electrons** (than chlorine) ✓ M2 *Relative force mark* Bromine has stronger (**OR** more) van der Waals' forces (between molecules) **OR** More energy is needed to break the van der Waals' forces in bromine ✓	2	**ALLOW** reverse argument throughout **ALLOW** chlorine has less **electron** shells **IGNORE** less shells **IGNORE** reference to chlorine has less shielding for M1 **ALLOW** vdW **ALLOW** 'intermolecular forces' **OR** 'dispersion forces' **OR** 'London Forces' **OR** induced dipole-dipole forces' for van der Waals' forces **ALLOW** 'less' for 'weaker' **DO NOT ALLOW** implication that any other attraction is broken for M2 eg Covalent bonds

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Question			Answer	Mark	Guidance
2	(c)		M1 *Mixing of first pair of solutions* Adding (aqueous) barium chloride to bromine (water) **OR** $BaCl_2 + Br_2$ M2 *Mixing of second pair of solutions* Adding (aqueous) calcium iodide to bromine (water) **OR** $CaI_2 + Br_2$ **OR** Adding aqueous magnesium bromide to aqueous iodine **OR** $MgBr_2 + I_2$ *M3 Colours in cyclohexane* Colour for M1 is orange **OR** yellow **AND** Colour for M2 is purple **OR** violet **OR** mauve **OR** pink **OR** lilac *M4 Ionic equation mark* $Br_2 + 2I^- \rightarrow I_2 + 2Br^-$ *M5 Use of M1 and **one** of M2 as only two experiments*	5	For M1 and M2 **ALLOW** any halide for the named halides in the question eg 'potassium chloride' for barium chloride 'potassium bromide' **DO NOT ALLOW** 'barium chlorine/BaCl' 'calcium iodine/CaI' 'magnesium bromine/MgBr' as the halide **DO NOT ALLOW** 'bromide' for 'bromine' **OR** 'iodide' for 'iodine' M1 can be seen anywhere M2 could be awarded from a correct ionic equation in M4 M2 can be seen anywhere If both M2 tests and M1 are given, this will nullify M5 M3 is given for the correct resultant colour of pairs of solution given in M1 and M2. If both possible pairs of solutions in M2 are given, both colours must be correct. **IGNORE** colours of other combinations of solutions **IGNORE** colours in the aqueous layer if stated **DO NOT ALLOW** other colours for M1 and M2 (eg iodine is brown) M4 can be awarded anywhere M4 also scores M2 if not already awarded **ALLOW** multiples **IGNORE** state symbols **IGNORE** $I_2 + 2Br^- \rightarrow I_2 + 2Br^-$ **IGNORE** $Br_2 + 2Cl^- \rightarrow Br_2 + 2Cl^-$ **DO NOT ALLOW** other ionic equations **DO NOT ALLOW** if more than two experiment are attempted even if pointless eg 'barium chloride + calcium iodide' Place the 'tick' for M5 against the sub-total mark, [5], at the bottom right hand side of the answer space
			Total	**11**	

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Question			Answer	Mark	Guidance
3	(a)		Periodicity ✓	1	
3	(b)		Sodium **OR** Na ✓ Silicon **OR** Si ✓ Neon **OR** Ne ✓	3	
3	(c)		Ga^{3+} ✓	1	
3	(d)		*M1 Number of bonding electrons mark* Magnesium has more outer **OR** bonding electrons ✓ *M2 Ionic charge mark* Magnesium **ions** have a greater (positive) charge (density) ✓ *M3 Attraction mark* Magnesium has a greater attraction between ions and delocalised electrons ✓	3	**ALLOW** reverse argument throughout **ALLOW** 'more delocalised electrons' for 'more outer electrons' **DO NOT ALLOW** 'Magnesium molecules' for M1 **ALLOW** Mg^{2+} ion **OR** Mg ion for 'magnesium ion' **ALLOW** Mg^{2+} **and** Na^{+} for M2 (may be seen in a diagram) **IGNORE** magnesium has a greater charge but **ALLOW** magnesium has a greater ionic charge **IGNORE** nuclear charge **DO NOT ALLOW** 'atoms' or 'molecules' having a greater charge for M2 **ALLOW** 'stronger metallic bonds' **only** when a clear description of metallic bonding is given. Eg 'The attraction of positive (metal) ions to delocalised electrons' QWC 'delocalised/delocalized' spelled correctly at least once in context of M3 (may be seen in M1 but used in M3) 'delocalised' need not be directly next to electrons eg Mg has more delocalised electrons and the ions have a greater attraction to these electrons would secure M3

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Question			Answer	Mark	Guidance
3	(e)		First check the answer line. If answer = 1200 cm^3 award 3 marks. Mol of $Mg(NO_3)_2$ = $\frac{2.966}{148.3}$ = 2(.00) x 10^{-2} **OR** 0.02(00) mol✓ Mol of gas = 2(.00) x 10^{-2} x 5/2 = 5(.00) x 10^{-2} **OR** 0.05(00) mol ✓ Vol of Gas = 0.05 x 24 000 = 1200 cm^3 ✓	3	If answer = 960 cm^3 award 2 marks. If answer = 240 cm^3 award 2 marks. **ALLOW** ECF for answers to at least two significant figures up to calculator value, correctly rounded **ALLOW** separate numbers of mol of each gas for M2 (0.04(00) mol NO_2 **and** 0.0100 mol O_2) **ALLOW** a second mark if only volume of O_2 (240 cm^3) **OR** only volume of NO_2 (960 cm^3) is calculated
3	(f)	(i)	SF_6 **AND** Sulfur(**VI**) fluoride **OR** Sulfur **hexa**fluoride ✓	1	**IGNORE** sulfur fluoride
		(ii)	$2F_2 + 2NaOH \rightarrow F_2O + 2NaF + H_2O$ M1 F_2O AND NaF ✓ M2 Rest of equation (including balance) ✓	2	**ALLOW** multiples **IGNORE** state symbol **ALLOW** OF_2 for F_2O **AND** FNa for NaF **ALLOW** both marks for alternative equations which have both F_2O and NaF **AND** three products Eg $3F_2 + 2NaOH \rightarrow 2F_2O + 2NaF + H_2$ Eg $2F_2 + NaOH \rightarrow F_2O + NaF + HF$
3	(g)	(i)	δ– on each F **AND** δ+ on O ✓	1	**ALLOW** δ2+ **OR** δ+ δ+ on O
		(ii)	Shape: non-linear **AND** Bond angle: 104.5 ^{o} ✓	1	For shape **ALLOW** alternative words eg 'V-shaped' 'bent' 'angular'. In the absence of words allow a diagram with a non-linear shape F – O – F bond angle > 90°. For bond angle **ALLOW** 106> bond angle ≥102 (Actual = 102°)
		(iii)	+2 ✓	1	**ALLOW** 2+
			Total	**17**	

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Question			Answer	Mark	Guidance
4	(a)		$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2$ ✓	1	**ALLOW** $4s^2\ 3d^{10}$
4	(b)	(i)	M1 The (weighted) mean **mass** of an **atom** (of an element) ✓ M2 Compared with $1/12^{th}$ (the mass) ✓ M3 Of (one atom of) carbon-12 ✓	3	**ALLOW** 'average' for 'mean' **ALLOW** 'mean mass of isotope**s**' but **DO NOT ALLOW** 'mean mass of isotope' (singular) **DO NOT ALLOW** 'mean mass of an element' For M2 and M3 **ALLOW** compared with the mass of carbon-12 which is 12 **ALLOW** for three marks Mass of **one mole** of **atoms** Compared to $1/12^{th}$ (mass of) **one mole OR 12 g** of carbon-12 **ALLOW** for three marks Mass of **one mole** of **atoms** $1/12^{th}$ (mass of) **one mole OR 12 g** of carbon-12
4	(b)	(ii)	First check the answer line. If answer = 65.44 award 2 marks. $\frac{(64 \times 49.0) + (66 \times 27.9) + (67 \times 4.3) + (68 \times 18.8)}{100}$ **OR** 31.36(0) + 18.414 + 2.881 + 12.784 **OR** 65.439 ✓ = 65.44 ✓	2	**ALLOW** one mark for ECF from transcription error in the first sum provided the final answer is to **two** decimal places and is between 64 and 68 and is a correct calculation of the transcription
4	(c)	(i)	Effervescence **OR** fizzing **OR** bubbling **OR** gas produced **AND** The solid **OR** zinc carbonate would dissolve **OR** disappear ✓	1	**ALLOW** 'carbon dioxide produced' **DO NOT ALLOW** incorrectly named gas eg H_2

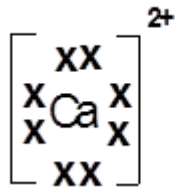
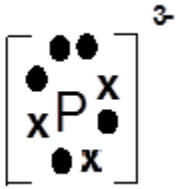
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Question			Answer	Mark	Guidance
4	(c)	(ii)	$ZnCO_3 + 2HCl \rightarrow ZnCl_2 + CO_2 + H_2O$ ✓	1	**ALLOW** multiples **IGNORE** state symbols
4	(d)	(i)	Magnesium (atoms) has been oxidised **AND** Because it has lost **two** electrons ✓ Copper (ions) has been reduced **AND** Because it has gained **two** electrons ✓	2	**IGNORE** use of oxidation numbers if electron gain/loss is mentioned. Electrons gain/loss could be in half equations In the absence of text look for evidence on the equation **ALLOW** 'donated' for 'lost' Assume 'Cu' refers to copper in '$CuSO_4$' **ALLOW** one mark **two** electrons gained and lost for each species but oxidation/reduction is incorrect or is omitted **ALLOW** one mark for correct oxidation and reduction if electron transfer is **omitted** and correct changes of oxidation state are shown (ie Mg 0 --> (+)2 **AND** Cu (+)2 to 0) **ALLOW** '**two** electrons transferred from magnesium to copper'
4	(d)	(ii)	$Mg(s) + 2H_2O(l) \rightarrow Mg(OH)_2(aq) + H_2(g)$ Correct reactants and products ✓ Balance and state symbols ✓	2	**ALLOW** multiples **ALLOW** $Mg(OH)_2(s)$ **ALLOW** $Mg(s) + H_2O(g)$ **OR** $H_2O(l) \rightarrow MgO(s) + H_2(g)$ including state symbols for **one** mark

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Question			Answer	Mark	Guidance
4	(e)		First check the answer line. If answer = 0.120 award 4 marks. M1 Mol of H_2SO_4 = $3.00 \times 10^{-2} \times \frac{35.0}{1000} = 1.05 \times 10^{-3}$ mol ✓ M2 Mol of $Al_2(SO_4)_3$ = $\frac{1.05 \times 10^{-3}}{3} = 3.5(0) \times 10^{-4}$ mol ✓ M3 = 342.3 ✓ M4 Mass $Al_2(SO_4)_3$ = $3.5(0) \times 10^{-4} \times 342.3$ **and** = 0.120 g ✓ **Answer must be 3 sf**	4	**ALLOW** ECF **ALLOW** 0.00105 mol **ALLOW** 0.00035(0) mol **ALLOW** 342 **DO NOT ALLOW** 0.12
4	(f)	(i)	$Ca(OH)_2$ **OR** Calcium hydroxide **OR** CaO **OR** Calcium oxide ✓	1	**ALLOW** Calcium carbonate **OR** $CaCO_3$
4	(f)	(ii)	$6Ca + P_4 \rightarrow 2Ca_3P_2$ ✓	1	**ALLOW** multiples **IGNORE** state symbols

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Question			Answer	Mark	Guidance
		(iii)	3x  2x  Ca with 8 (or no) electrons AND phosphide ion with dot-and-cross outermost octet ✓ Three Ca ions **AND** two phosphide ions with correct charges ✓	2	For first mark: If 8 electrons are shown on the cation then the extra electron in the anion must match the symbol chosen for the electrons in the cation. **IGNORE** inner shells **IGNORE** circles **ALLOW** one mark if both electron arrangements and charges are correct but only one of each ion is drawn. **ALLOW** (brackets not required) $3[Ca^{2+}]$ $3[Ca]^{2+}$ $[Ca^{2+}]_3$ $2[P^{3-}]$ $2[P]^{3-}$ $[P^{3-}]_2$ **DO NOT ALLOW** $[Ca_3]^{2+}$ $[3Ca]^{2+}$ $[Ca]_3^{2+}$ $[P_2]^{3-}$ $[2P]^{3-}$ $[P]_2^{3-}$
			Total	**20**	

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Oxford Cambridge and RSA

Friday 22 May 2015 – Morning

AS GCE CHEMISTRY A

F321/01 Atoms, Bonds and Groups

Candidates answer on the Question Paper.

OCR supplied materials:
- *Data Sheet for Chemistry A* (inserted)

Other materials required:
- Scientific calculator

Duration: 1 hour

* F 3 2 1 0 1 *

* 4 9 8 9 2 4 7 7 7 9 *

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The Insert will be found inside this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional answer space is required, you should use the lined page at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
-  Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry A* 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**.
- This document consists of **16** pages. Any blank pages are indicated.

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Answer **all** the questions.

1 This question is about the elements with atomic numbers between 58 and 70.

(a) Cerium, atomic number 58, is a metal.

Complete the table to show the relative charge of each particle and the number of each particle found in a $^{140}Ce^{2+}$ ion.

Particle	Relative charge of each particle	Number of each particle present in a $^{140}Ce^{2+}$ ion
proton		
neutron		
electron		

[2]

(b) Cerium behaves as a typical metal when it reacts with dilute sulfuric acid to form the salt cerium(III) sulfate and a second product.

(i) Identify the second product.

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

(ii) Write the formula of cerium(III) sulfate and, explain what has happened to the cerium in this reaction in terms of the number of electrons transferred.

Formula .....

Explanation .....

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

(iii) How has a salt been formed in this reaction?

.....

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

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(c) Europium, atomic number 63, reacts with oxygen at room temperature.

$$4Eu + 3O_2 \rightarrow 2Eu_2O_3$$

Calculate the volume of oxygen, in cm^3, required to fully react with 9.12 g of europium at room temperature and pressure.

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

(d) A compound of thulium, atomic number 69, has the following composition by mass:

O 30.7% S 15.4% Tm 53.9%

(i) State what is meant by the term *empirical formula*.

.....

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

(ii) Determine the empirical formula of the compound.

Show your working.

Empirical formula = ... **[2]**

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(e) Ytterbium, atomic number 70, is the first element in the Periodic Table to have the first four shells full.

(i) State the number of electrons in the **fourth** shell of ytterbium.

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

(ii) How many orbitals are there in the **third** shell of ytterbium?

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

[Total: 13]

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2 This question is about compounds of Group 3 elements.

(a) Aluminium will combine directly with fluorine.

Write the equation for the reaction between aluminium and fluorine.

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

(b) Solid aluminium fluoride has a giant ionic lattice structure.

(i) Describe what is meant by the term *ionic lattice*, in terms of the type and arrangement of particles present.

.....

.....

.....

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

(ii) Draw a '*dot-and-cross*' diagram for aluminium fluoride.

Show outer electrons only.

[2]

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(c) Solid boron tribromide has a simple molecular lattice structure. The atoms are held together by covalent bonds.

(i) What is meant by the term *covalent bond*?

.....

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

(ii) Draw a '*dot-and-cross*' diagram to show the bonding in a boron tribromide molecule.

Show outer electrons only.

[1]

(d) State whether the following substances conduct electricity when solid or molten, and explain your answers in terms of the particles involved:

- aluminium
- aluminium fluoride
- boron tribromide.

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

.....

.....

.....

.....

.....

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.....

.....

.....

..... **[5]**

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(e) Aluminium has 13 successive ionisation energies.

(i) Write the equation for the **third** ionisation energy of aluminium.

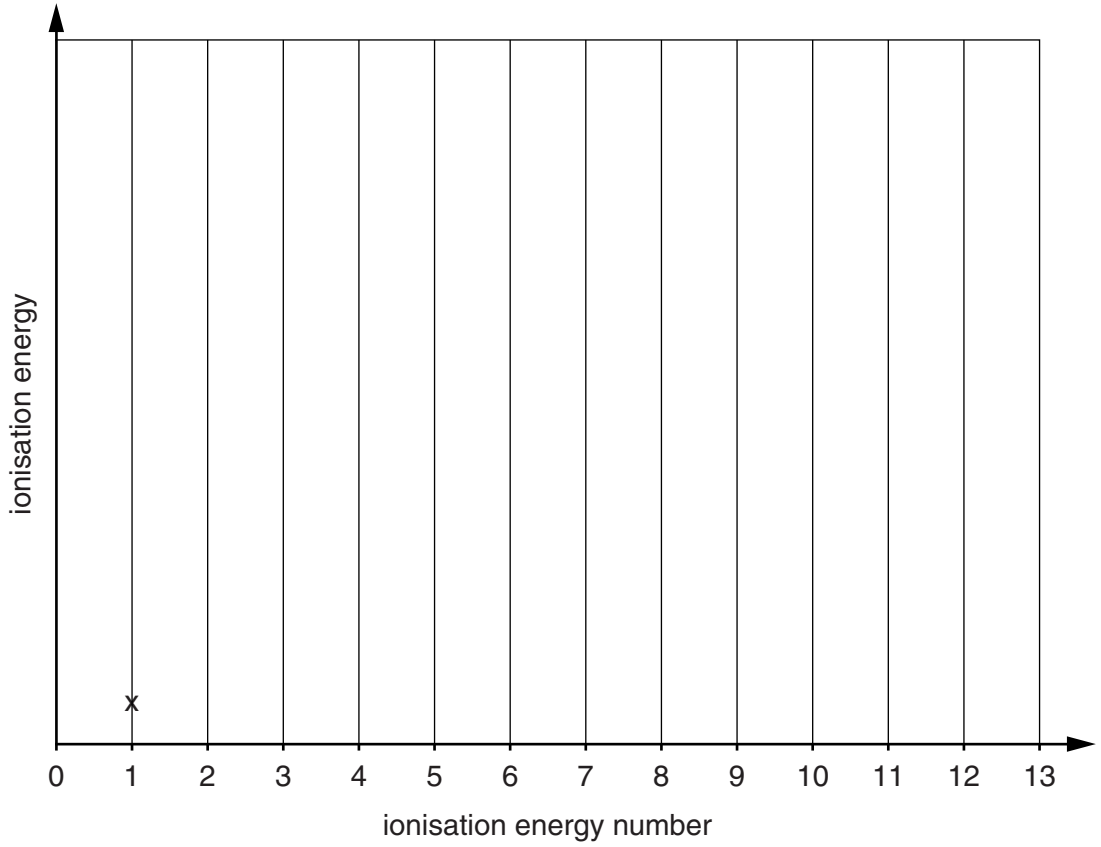
Include state symbols.

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

(ii) On the axes below, add crosses to show the 13 successive ionisation energies of aluminium.

The value for the first ionisation energy has been completed for you.

You do not have to join the crosses.



[2]

[Total: 15]

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3 This question is about Group 7 elements.

(a) Chlorine can be made by the redox reaction below.

$$MnO_2(s) + 4HCl(aq) \rightarrow MnCl_2(aq) + 2H_2O(l) + Cl_2(g)$$

Using oxidation numbers, show what has been oxidised and what has been reduced in this reaction.

Oxidised .....

.....

Reduced .....

.....

[2]

(b) Complete the electron configuration of a manganese atom.

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

(c) Chlorine gas can be added to a cold, dilute alkaline solution to form bleach.

Write the equation for this reaction.

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

(d) A student bubbles chlorine gas through aqueous potassium iodide. A reaction takes place.

(i) State what the student would observe.

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

(ii) Write the ionic equation for this reaction.

Include state symbols.

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

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(e) Chlorine gas reacts with methane. One of the products is dichloromethane, CH_2Cl_2.

(i) Chlorine is more electronegative than carbon and hydrogen, which have approximately equal electronegativity values.

Explain what is meant by the term *electronegativity.*

.....

.....

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

(ii) Draw a 3-D diagram of a molecule of CH_2Cl_2.

Use partial charges to indicate polar bonds.

[2]

(iii) Explain why a CH_2Cl_2 molecule is polar.

.....

.....

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

(f) Bromine has two isotopes, Br–79 and Br–81. The relative atomic mass of bromine is 79.9.

Calculate the percentage of Br–79 atoms in a sample of bromine.

Answer = ... % **[1]**

[Total: 12]

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4 A student was given 200 cm^3 of solution **X** in which sodium hydroxide, NaOH, and sodium hydrogencarbonate, $NaHCO_3$, had **both** been dissolved.

The student carried out **two different** titrations on samples of solution **X** using 0.100 mol dm^{-3} sulfuric acid, H_2SO_4.

- In the first titration, **both** NaOH **and** $NaHCO_3$ were neutralised.
- In the second titration, **only** NaOH was neutralised.

The student's results for the titrations of 25.0 cm^3 samples of solution **X** are shown.

volume of H_2SO_4 needed to neutralise **both** NaOH **and** $NaHCO_3$	29.50 cm^3
volume of H_2SO_4 needed to neutralise **only** NaOH	18.00 cm^3

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

$$2NaHCO_3(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l) + 2CO_2(g)$$

(a) (i) Calculate the amount, in mol, of H_2SO_4 used to neutralise **only** the NaOH in 25.0 cm^3 of solution **X**.

Amount = ... mol **[1]**

(ii) Calculate the concentration, in mol dm^{-3}, of NaOH in solution **X**.

Concentration = ... mol dm^{-3} **[1]**

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(b) (i) Calculate the amount, in mol, of $NaHCO_3$ in the 200 cm^3 of solution **X**.

Amount = ... mol **[2]**

(ii) Calculate the mass of $NaHCO_3$ in the 200 cm^3 of solution **X**.

Give your answer to **three** significant figures.

Mass = ... g **[1]**

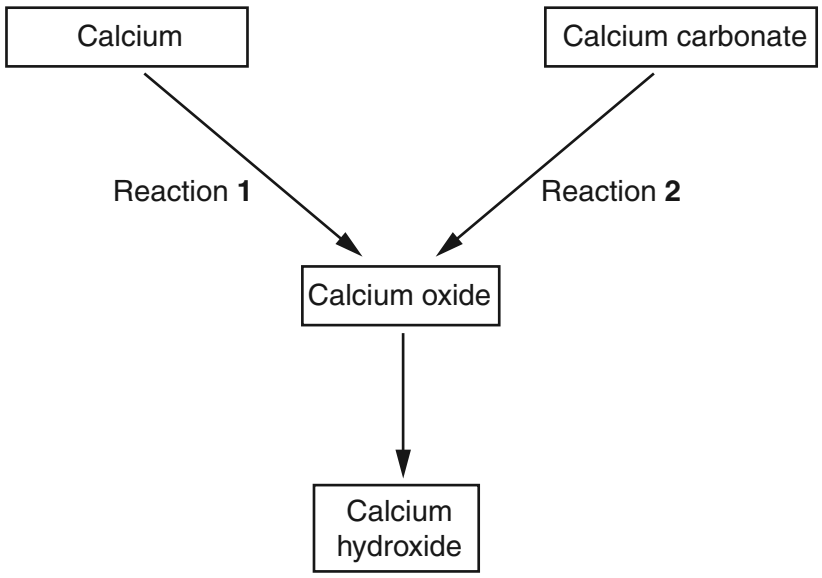
[Total: 5]

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5 Calcium is in Group 2 of the Periodic Table.

The diagram shows some reactions of calcium and its compounds.



(a) Reactions **1** and **2** both form calcium oxide.

(i) Write the equation for reaction **1**.

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

(ii) What type of reaction is reaction **2**?

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

(b) Calcium hydroxide is both a base and an alkali. Refer to any relevant ions in your answer.

Explain what is meant by the terms *base* and *alkali*.

Base .....

.....

Alkali .....

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

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(c) A student prepared some calcium hydroxide by adding a small piece of calcium to a large excess of water.

Describe what the student would observe and write the equation for the reaction.

Observation .....

.....

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

(d) A student prepares a solution of calcium nitrate from calcium carbonate.

What reagent would the student need to use?

Write the equation for the reaction.

Reagent .....

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

[Total: 8]

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6 This question is about the attraction between particles.

(a) State how and explain why the attraction between nuclei and outermost electrons in gaseous atoms varies across Period 3.

.....

.....

.....

.....

.....

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

(b) The table shows the boiling points of ammonia, fluorine and bromine.

	Boiling point/°C
ammonia, NH_3	– 33
fluorine, F_2	– 188
bromine, Br_2	59

Explain the different boiling points of NH_3, F_2 and Br_2.

Include the names of any relevant forces and particles.

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

.....

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..... **[5]**

[Total: 7]

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page. The question number(s) must be clearly shown in the margins.

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GCE

Chemistry A

Unit **F321:** Atoms, Bonds and Groups

Advanced Subsidiary GCE

Mark Scheme for June 2015

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

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Annotations available in Scoris.

Annotation	Meaning
BOD	Benefit of doubt given
CON	Contradiction
	Incorrect response
ECF	Error carried forward
I	Ignore
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error
SF	Error in number of significant figures
	Correct response

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

The following questions should be annotated with ticks to show where marks have been awarded in the body of the text:

Q2d Q6b

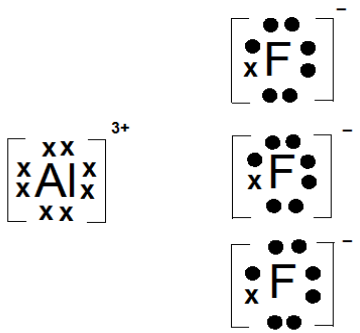
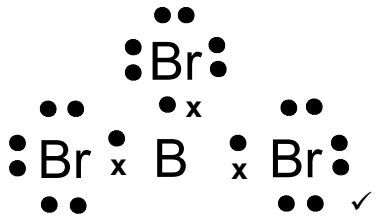
<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td>(i)</td><td>
<table>
<tr><th>Particle</th><th>Relative charge</th><th>Number of particles present in a $^{140}Ce^{2+}$ ion.</th></tr>
<tr><td>Protons</td><td>+1</td><td>58</td></tr>
<tr><td>Neutrons</td><td>Nil (or 0)</td><td>82</td></tr>
<tr><td>Electrons</td><td>–1</td><td>56</td></tr>
<tr><td>One mark per column</td><td>✓</td><td>✓</td></tr>
</table>
</td><td>2</td><td>DO NOT ALLOW ‘+’ or ‘-‘ without ‘1’
DO NOT ALLOW 1 without charge
ALLOW 1+ AND 1–
IGNORE ‘–‘ (ie a dash) for relative charge of a neutron</td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td>Hydrogen ✓</td><td>1</td><td>ALLOW H_2
IGNORE ‘H’</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>$Ce_2(SO_4)_3$ ✓

(Cerium) loses three electrons (to form 3+ ion) ✓</td><td>2</td><td>ALLOW alternative phrases for ‘loses’ eg ‘gives away’, ‘donates’
IGNORE ‘3 electrons transferred’ unless a correct direction is given eg ALLOW (Ce) transfers 3 electrons to … OR (Ce) transfers 3 electrons forming Ce^{3+}
IGNORE references to sulfate gaining electrons
IGNORE references to reduction and oxidation</td></tr>
<tr><td></td><td></td><td>(iii)</td><td>A hydrogen ion (of an acid) has been replaced by a metal ion ✓</td><td>1</td><td>For hydrogen ion:
ALLOW ‘H^+’ OR ‘proton’
but DO NOT ALLOW ‘H’ OR ‘hydrogen’ without ‘ion’
For metal ion:
ALLOW ‘cerium ion’ OR ‘Ce^{3+}’ OR ‘Ce^{2+}’ OR ‘Ce ion’
But DO NOT ALLOW ‘Ce’ without ‘ion’ OR ‘cerium’ without ‘ion’
IGNORE ‘ammonium ion’</td></tr>
</table>

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Question			Answer	Mark	Guidance
	(c)		**Check the answer line.** **If answer = 1080 cm^3 award 2 marks** Amount of Eu = 9.12/ 152.0 = 0.06(00) mol ✓ Amount of O_2 = 0.0600 x 3/4 = 0.045(0) mol **and** Volume of O_2 = 0.0450 x 24000 = 1080 cm^3 ✓	2	**If there is an alternative answer, check to see if there is any ECF credit possible using working below.** **ALLOW** calculator value or rounding to 2 significant figures or more but **IGNORE** 'trailing zeroes' eg 0.200 is allowed as 0.2. **ALLOW** incorrectly calculated *amount* of Eu x 3/4 and x 24000 correctly calculated for 2nd mark Eg 2605.7 would come from (9.12/63) x 3/4 x 24000 (note: a mass of Eu x 3/4 and x 24000 would not score M2)
1	(d)	(i)	The simplest **whole** number ratio of **atoms** (of each element) present in a compound ✓	1	**ALLOW** smallest **OR** lowest for simplest **ALLOW** molecule for compound
		(ii)	**Check the answer line.** **If answer = $O_{12}S_3Tm_2$ award 2 marks** O = 30.7/ 16.0 S 15.4/32.1 Tm = 53.9 / 168.9 **OR** 1.9(2) mol 0.480 mol 0.319 mol ✓ $O_{12}S_3Tm_2$ ✓	2	**ALLOW** 0.479 OR 0.48 for mol of S **ALLOW** 0.32 for mol of Tm **DO NOT ALLOW** $Tm_2(SO_4)_3$ as empirical formula **IGNORE** $Tm_2(SO_4)_3$ if seen in working.
	(e)	(i)	32 ✓	1	
		(ii)	9 ✓	1	
			Total	**13**	

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Question			Answer	Mark	Guidance
2	(a)		$2Al + 3F_2 \rightarrow 2AlF_3$ ✓	1	**ALLOW** multiples **IGNORE** state symbols
	(b)	(i)	Repeating pattern ✓ of oppositely charged ions ✓	2	**ALLOW** 'regular' **OR** 'alternating' **OR** 'uniform (arrangement)' for 'repeating pattern' **ALLOW** positive and negative ions **OR** aluminium ions and fluoride ions **ALLOW** oppositely charged ions from a labelled diagram
		(ii)	 Al with 8 (or no) outermost electrons **AND** 3 x fluoride (ions) with '*dot-and-cross*' outermost octet ✓ Correct charges ✓	2	For first mark: If 8 electrons are shown in the cation then the 'extra' electron in the anion must match the symbol chosen for the electrons in the cation **IGNORE** inner shells **IGNORE** circles **ALLOW** one mark if both electron arrangements and charges are correct but only one F is drawn. **ALLOW** one mark if incorrect symbol is the only error, unless ECF from 2(a) in which both marks are available **DO NOT ALLOW** any marks for BF_3 **ALLOW** $3[F^-]$ $3[F]^-$ $[F^-]_3$ (brackets not required) **DO NOT ALLOW** $[F_3]^-$ $[F_3]^{3-}$ $[3F]^{3-}$ $[F]_3^-$
	(c)	(i)	A shared pair of electrons.	1	
	(c)	(ii)	 ✓	1	

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Question	Answer	Mark	Guidance
(d)	*Conductivity of Al mark* M1: Aluminium conducts in solid and molten states ✓ *Reason for conductivity of Al mark* M2: Aluminium has delocalised electrons ✓ *Conductivity and reason for molten AlF_3 mark* M3: Aluminium fluoride conducts when molten **AND** because it has mobile **ions** ✓ *Conductivity and reason for solid AlF_3 mark* M4: Aluminium fluoride does not conduct when solid **AND** Solid aluminium fluoride has **ions** which are fixed (in position) **OR ions** are held (in position) **OR ions** are not mobile **AND** In an (ionic) lattice **OR** (ionic) structure **OR** by (ionic) bonds ✓	5	**ALLOW** 'carries charge' for conducts **IGNORE** 'charge carriers' for 'electrons' or 'ions' for M2, M3 and M4. *Quality of written communication:* 'delocalis(z)ed' spelled correctly and used in context for the second marking point. **DO NOT ALLOW** M2 if incorrect bonding is seen for Al **DO NOT ALLOW** 'ions move' for solid Al. **IGNORE** 'ions move' for molten Al. **IGNORE** references to 'aqueous' AlF_3 for M3 **IGNORE** 'delocalised ions' **OR** 'free ions' for mobile ions in M3 **DO NOT ALLOW** M3 if incorrect bonding is seen in AlF_3 **DO NOT ALLOW** any mention of electrons moving for M3 **DO NOT ALLOW** suggestion that it is only positive or only negative ions moving for M3 For conductivity parts of M3 + M4 **ALLOW** 'AlF_3 only conducts when molten' **ALLOW** Solid AlF_3 is a poor conductor for M4 **ALLOW** second and third statements to be unlinked in separate sentences for M4 **IGNORE** 'there are no delocalised electrons' for M4 **DO NOT ALLOW** M4 if incorrect bonding is seen in AlF_3 Lattice **OR** structure **OR** ionic bonds can be seen anywhere in relation to AlF_3. **ALLOW** Solid BBr_3 is a poor conductor for M5 **ALLOW** electrons are fixed in position **OR** used in bonds

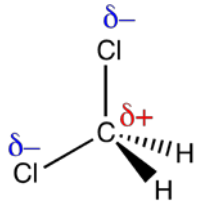
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Question			Answer	Mark	Guidance
			Conductivity and reason for BBr_3 mark M5 Boron tribromide does not conduct in solid and molten states **AND** Boron tribromide has no mobile electrons **OR** no (mobile) ions **OR** no mobile charge carriers **OR** no mobile charged particles ✓		**IGNORE** 'there are no delocalised electrons' **OR** 'there are no free electrons' for M5 **DO NOT ALLOW** M5 if incorrect bonding is seen in BBr_3 eg 'ions are fixed in position' **ALLOW** 'no (free) ions'
2	**(e)**	**(i)**	$Al^{2+}(g) \rightarrow Al^{3+}(g) + e^{-}$ ✓	1	State symbols required (ignore states on electrons) **ALLOW** $Al^{2+}(g) - e^{-} \rightarrow Al^{3+}(g)$ **ALLOW** e for e^{-}
		(ii)	All (thirteen) ionisation energies show an increase ✓ The two largest increases are between the third and fourth **AND** the eleventh and twelfth ionisation energies ✓	2	**IGNORE** line if drawn **IGNORE** 0 if included **ALLOW** one mark for three lines (no crosses) showing an increase between: first and third; fourth and eleventh; twelfth and thirteenth **AND** Largest increases between each line **ALLOW** crosses outside grid
			Total	**15**	

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Question			Answer	Mark	Guidance
3	(a)		Cl (has been oxidised) from Cl = –1 to Cl = 0 ✓ Mn (has been reduced) from Mn = +4 to Mn = +2 ✓	2	**ALLOW** 4+ **OR** 4 **OR** 2+ **OR** 2 **ALLOW** oxidation numbers written above the equation but **IGNORE** these if oxidation numbers are given in the text **ALLOW** one mark for Cl is oxidised because the oxidation number increased by 1 **AND** Mn is reduced because the oxidation number decreased by 2 **ALLOW** one mark if all oxidation numbers are correct but redox is incorrect. **IGNORE** HCl is oxidised **AND** MnO_2 is reduced **IGNORE** correct references to electron loss/gain **DO NOT ALLOW** incorrect references to electron loss/gain
	(b)		$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$ ✓	1	**ALLOW** $4s^2\ 3d^5$ **IGNORE** $1s^2$ seen twice
	(c)		$Cl_2 + 2NaOH \rightarrow NaClO + NaCl + H_2O$ ✓	1	**ALLOW** multiples **IGNORE** state symbols **ALLOW** OH^- and ClO^-, i.e. $Cl_2 + 2OH^- \rightarrow ClO^- + Cl^- + H_2O$ **ALLOW** NaOCl
3	(d)	(i)	(The solution would turn) yellow **OR** orange **OR** brown ✓	1	**ALLOW** shades and colours (eg dark yellow, yellow-orange) **DO NOT ALLOW** 'purple'
	(d)	(ii)	$Cl_2\ (g) + 2I^-\ (aq) \rightarrow I_2\ (aq) + 2Cl^-\ (aq)$ ✓	1	**ALLOW** multiples State symbols required **ALLOW** $Cl_2(aq)$
	(e)	(i)	The ability of an atom to attract electrons ✓ (Electron pair) in a (covalent) bond ✓	2	**ALLOW** 'Measure' for ability **ALLOW** 'attraction' for 'ability to attract' **ALLOW** 'The ability of an atom to attract a shared pair of electrons' for two marks

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Question			Answer	Mark	Guidance
3	(e)	(ii)	 Correct orientation of 3-D tetrahedral arrangement of bonds around C atom ✓ δ+ on C atom **AND** δ– on both Cl atoms ✓	2	For a 3D structure, For bond in the plane of paper, a solid line is expected: For bond out of plane of paper, a solid wedge is expected: For bond into plane of paper, **ALLOW**: **ALLOW** a hollow wedge for 'in bond' **OR** an 'out bond', provided it is different from the other in or out wedge e.g.: **ALLOW** any 3D representation with a minimum of one bond into the plane of paper **AND** minimum of one out of plane of paper **ALLOW** 2 lines in the plane + 2 different bonds for M1 **IGNORE** dipole charges on H
		(iii)	The dipoles do not cancel out **OR** Because the molecule is non-symmetrical ✓	1	**ALLOW** partial charges do not cancel **IGNORE** charges do not cancel **ALLOW** (the more) electronegative atoms are on one side of the molecule
	(f)		55% ✓	1	
			Total	**12**	

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Question			Answer	Mark	Guidance
4	(a)	(i)	Mol of H_2SO_4 = 0.100 x 18.00/1000 = 1.80 x 10^{-3} mol ✓	1	**ALLOW** calculator value or rounding to 2 significant figures or more but **IGNORE** 'trailing zeroes' throughout Q4. eg 0.200 is allowed as 0.2
		(ii)	Mol of NaOH in = 1.80 x 10^{-3} x 2 x 1000/25.0 = 0.144 mol dm^{-3} ✓	1	**ALLOW** ECF for (a)(i) x 2 x 1000/25
	(b)	(i)	**Check the answer line.** **If answer = 0.0184 mol award 2 marks** Mol of $NaHCO_3$ in 25.0 cm^3 = [0.100 x 11.50/1000] x 2 = 0.00230 mol ✓ Mol of $NaHCO_3$ in 200 cm^3 = 0.00230 x 200/25.0 = 0.0184 mol ✓	2	**If there is an alternative answer, check to see if there is any ECF credit possible using working below.** **ALLOW** for an alternative method for M1 Total mol of H_2SO_4 used = [0.100 x 29.50/1000] = 0.00295 mol Mol of H_2SO_4 reacting with $NaHCO_3$ = 0.00295 – answer to (a)(i) Expected answer = .00295 – 0.00180 = 0.00115 mol Mol of $NaHCO_3$ in 25.0 cm^3 = 0.00115 x 2 = 0.00230 mol **ALLOW** ECF for **mol** of $NaHCO_3$ x 200/25.0 For ECF in M2 titration values of 11.50 or 29.50 must have been used in M1 Second marking point is for scaling up number of mol of $NaHCO_3$ by 200/25.0 (Usually seen as '8')
		(ii)	Mass of $NaHCO_3$ = 0.0184 x 84.0 = 1.55 g ✓ **(must be three significant figures)**	1	**ALLOW** ECF for **(b)(i)** x 84.0 correctly calculated and rounded to three significant figures.
			Total	**5**	

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Question			Answer	Mark	Guidance
5	(a)	(i)	$2Ca + O_2 \rightarrow 2CaO$ ✓	1	**ALLOW** multiples e.g. $Ca + ½O_2 \rightarrow CaO$ **IGNORE** state symbols
		(ii)	Thermal decomposition ✓	1	
	(b)		Base: A substance which readily accepts H^+ ions (from an acid) ✓ Alkali: releases OH^- ions into (aqueous) solution ✓	2	**ALLOW** proton acceptor **ALLOW** Is soluble and releases OH^- ions (into aqueous solution)
	(c)		Effervescence **OR** fizzing **OR** bubbling **OR** gas produced **AND** The solid **OR** calcium **OR** the metal would dissolve **OR** disappear **OR** a (colourless) solution forms ✓ $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$ ✓	2	**IGNORE** 'hydrogen produced' but **ALLOW** 'hydrogen gas produced' **DO NOT ALLOW** an incorrectly named gas (eg CO_2) produced **ALLOW** multiples **IGNORE** state symbols
	(d)		Nitric acid **OR** HNO_3 ✓ $CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$ ✓	2	**ALLOW** reagent mark if no response is seen but HNO_3 is seen in the equation **IGNORE** calcium carbonate on reagent line **ALLOW** multiples **IGNORE** state symbols **DO NOT ALLOW** H_2CO_3 for $H_2O + CO_2$
			Total	8	

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Question			Answer	Mark	Guidance
6	(a)		The attraction (between nuclei and outermost electrons) increases (across the period) **AND** The nuclear charge increases **OR** The number of protons increase ✓ (Outer) electrons are in the same shell **OR** (Outer) electrons experience similar shielding **OR** Same number of shells **OR** Atomic radius decreases ✓	2	**ALLOW** There is no change in shielding But **DO NOT ALLOW** 'there is no shielding' **DO NOT ALLOW** electrons are at the same distance

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Question	Answer	Mark	Guidance
(b)		5	*Quality of written communication:* 'molecule(s)' or 'intermolecular' spelled correctly once and used in context for the third marking point.
	M1 NH_3 forces mark NH_3 has hydrogen bonding ✓		**ALLOW** H-bonding for hydrogen bonding **IGNORE** van der Waals' forces **AND** permanent dipoles in M1 **IGNORE** covalent bonds for M1 **AND** M2
	*M2 F_2 **AND** Br_2 forces mark* F_2 **AND** Br_2 have van der Waals' (forces) ✓		**ALLOW**, for van der Waal's: vdWs **OR** induced dipole temporary **OR** instantaneous dipole (-dipole) forces **ALLOW** for forces: attractions **OR** interactions; **DO NOT ALLOW** M3, M4 or M5 if covalent **OR** ionic bonds are the forces between the particles in that mark
	M3 Type of particle mark Forces **OR** attractions are between molecules **OR** are intermolecular for ammonia **AND** Forces **OR** attractions are between molecules **OR** are intermolecular for fluorine **OR** for bromine ✓		M3 can be seen anywhere eg in M1 NH_3 has hydrogen bonding between molecules **AND** the intermolecular force in Br_2 is stronger than that of F_2 eg a generic statement such as 'boiling point of these substances is determined by strength of *intermolecular bonding'* eg 'All these *molecules* are *held* together by weak forces'

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Question			Answer	Mark	Guidance
			M4 Br_2 / F_2 comparison mark The van der Waals' forces in Br_2 are greater than in F_2 **AND** Because bromine has more electrons than fluorine ✓		If correct force is given in M2 **ALLOW**, for M4, 'intermolecular force in Br_2 is stronger than that in F_2' **ALLOW** more van der Waals' for greater van der Waals' **ALLOW** more shells of electrons
			M5 Br_2 / NH_3 / F_2 comparison mark The van der Waals' forces in Br_2 are greater than hydrogen bonding in NH_3 **AND** hydrogen bonding in NH_3 is stronger than van der Waals' forces in F_2 ✓		**IGNORE** 'permanent dipoles' in NH_3 for M5 if quoted in addition to hydrogen bonding If correct force is given in M1 **AND** M2 **ALLOW**, for M5, 'intermolecular force in Br_2 is stronger than that in NH_3' **AND** 'intermolecular force in NH_3 is stronger than that in F_2' If incorrect intermolecular force is given in M1 **OR** M2 **ALLOW** this as ECF for M5 but **DO NOT ALLOW** if the comparison is based only on van der Waals' forces Eg **DO NOT ALLOW** the van der Waals' forces in bromine are stronger than those in ammonia which in turn are stronger than those in fluorine
			Total	**7**	

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Friday 23 May 2014 – Morning

AS GCE CHEMISTRY A

F321/01 Atoms, Bonds and Groups

Candidates answer on the Question Paper.

OCR supplied materials:
- *Data Sheet for Chemistry A* (inserted)

Other materials required:
- Scientific calculator

Duration: 1 hour

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The Insert will be found inside this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional answer space is required, you should use the lined page at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry A* 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**.
- This document consists of **12** pages. Any blank pages are indicated.

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Answer **all** the questions.

1 Antimony, Sb, has atomic number 51.

(a) Complete the table below to show where antimony is found in the Periodic Table.

Period	Block

[1]

(b) Antimony exists as a mixture of isotopes.

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

.....

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

(ii) Different isotopes of antimony have the same chemical properties.

Explain why.

.....

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

(iii) Complete the table below to show the atomic structure of ^{121}Sb.

Protons	Neutrons	Electrons

[1]

(c) The relative atomic mass of antimony is 121.8.

(i) Define the term *relative atomic mass*.

.....

.....

.....

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

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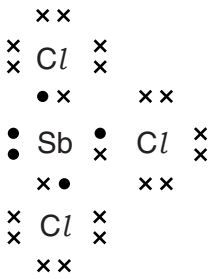
(ii) A sample of antimony, A_r = 121.8, was analysed and was found to consist of 60% ^{121}Sb and one other isotope.

Determine the mass number of the other isotope in the sample of antimony.

mass number of the other antimony isotope = ... **[1]**

(d) Antimony chloride, $SbCl_3$, exists as simple covalent molecules.

A *'dot-and-cross'* diagram of $SbCl_3$ is shown below.



(i) Predict the shape of a molecule of $SbCl_3$.

Explain your answer.

name of shape: .....

explanation: .....

.....

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

(ii) $SbCl_3$ molecules are polar.

Explain why.

.....

.....

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

[Total: 13]

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2 This question is about compounds used in fertilisers.

(a) A compound used as a fertiliser has the following composition by mass:

C, 20.00%; H, 6.67%; N, 46.67%; O, 26.66%.

Calculate the empirical formula of this compound.

empirical formula = ... **[2]**

(b) A salt used as a fertiliser has the empirical formula $H_4N_2O_3$.

Suggest the formulae of the ions present in this salt.

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

(c) Calcium phosphate(V), $Ca_3(PO_4)_2$, is another salt used in fertilisers.

Calcium phosphate(V) can be prepared by reacting together an acid and a base.

(i) Suggest the **formula** of the acid used to prepare $Ca_3(PO_4)_2$.

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

(ii) **Name** a base which could be used to prepare $Ca_3(PO_4)_2$.

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

[Total: 6]

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3 An aqueous solution of aluminium chloride can be prepared by the redox reaction between aluminium metal and dilute hydrochloric acid.

A student reacts 0.0800 mol of aluminium completely with dilute hydrochloric acid to form an aqueous solution of aluminium chloride.

The equation for this reaction is shown below.

$$2Al(s) + 6HCl(aq) \longrightarrow 2AlCl_3(aq) + 3H_2(g)$$

(a) In terms of electron transfer, explain whether aluminium is being oxidised or reduced.

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

(b) Calculate the volume of hydrogen gas formed, in dm^3, at room temperature and pressure.

volume of hydrogen gas formed = ... dm^3 **[2]**

(c) Calculate the mass of $AlCl_3$ formed.

Give your answer to **three** significant figures.

mass of $AlCl_3$ formed = ... g **[2]**

(d) Calculate the volume, in cm^3, of 1.20 mol dm^{-3} hydrochloric acid needed to react completely with 0.0800 mol of aluminium.

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

[Total: 7]

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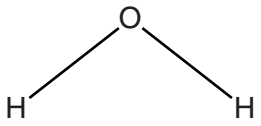
4 Oxides can have different types of bonding.

(a) H_2O has hydrogen bonding.

(i) Complete the diagram below to show hydrogen bonding between the H_2O molecule shown and **one** other H_2O molecule.

Include relevant dipoles and lone pairs.

Label the hydrogen bond.



[2]

(ii) State and explain **two** anomalous properties of ice caused by hydrogen bonding.

1 .....

.....

.....

2 .....

.....

.....

[4]

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(b) Draw a *'dot-and-cross'* diagram to show the bonding in CO_2.

Show outer electrons only.

[1]

(c) Silicon dioxide, SiO_2, has the same structure and bonding as diamond.

State the structure and bonding in SiO_2.

.....

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

(d) Describe and explain the electrical conductivity of sodium oxide, Na_2O, and sodium in their solid and molten states.



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

.....

.....

.....

.....

.....

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.....

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.....

.....

..... **[5]**

[Total: 13]

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5 The Periodic Table is arranged in periods and groups.

(a) Elements in the Periodic Table show a periodic trend in atomic radius.

State and explain the trend in atomic radius from Li to F.



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

trend .....

explanation .....

.....

.....

.....

.....

.....

[3]

(b) **(i)** Complete the electron configuration of a bromide **ion**.

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

(ii) A student adds a small volume of aqueous silver nitrate to an aqueous solution of bromide ions in a test-tube. The student then adds a similar volume of dilute aqueous ammonia to the same test-tube.

Describe what the student would see in the test-tube after the addition of aqueous ammonia.

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

(iii) Write an ionic equation for any precipitation reaction which occurs in the student's tests.

Include state symbols.

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

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(c) The Group 7 element chlorine reacts with sodium hydroxide, NaOH, under different conditions to give different products.

(i) Chlorine reacts with aqueous sodium hydroxide to form bleach.

Write the equation and state the conditions for this reaction.

equation .....

conditions .....

[2]

(ii) Under different conditions, chlorine reacts differently with aqueous sodium hydroxide.

A disproportionation reaction takes place as shown below.

$$3Cl_2(g) + 6NaOH(aq) \longrightarrow 5NaCl(aq) + NaClO_3(aq) + 3H_2O(l)$$

State what is meant by disproportionation and show that disproportionation has taken place in this reaction.

Use oxidation numbers in your answer.

.....

.....

.....

.....

.....

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

[Total: 11]

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6 This question is about Group 2 elements and compounds.

(a) Group 2 carbonates undergo thermal decomposition.

(i) Write the equation for the thermal decomposition of calcium carbonate.

Include state symbols.

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

(ii) Write the formula of the Group 2 carbonate which decomposes at the highest temperature.

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

(b) Hydrated strontium chloride, $SrCl_2 \bullet 6H_2O$, has a molar mass of 266.6 g mol^{-1}.

A student heats 5.332 g of $SrCl_2 \bullet 6H_2O$.

The $SrCl_2 \bullet 6H_2O$ loses some of its water of crystallisation forming 3.892 g of a solid product.

Use the information above to determine the formula of the solid product.

Show your working.

formula of solid product = ... **[3]**

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(c) A chemist carries out reactions of barium and barium nitride, Ba_3N_2.

Reaction 1 Barium is reacted with water.

Reaction 2 Barium nitride is reacted with water, forming an alkaline solution and an alkaline gas.

Reaction 3 Barium is reacted with an excess of oxygen at 500°C, forming barium peroxide, BaO_2.

(i) Write equations for **Reaction 1** and **Reaction 2**.

Ignore state symbols.

Reaction 1: .....

Reaction 2: .....

[3]

(ii) Predict the structure and bonding of Ba_3N_2.

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

(iii) BaO_2 formed in **Reaction 3** contains barium and peroxide ions.
The peroxide ion has the structure $[O–O]^{2–}$.

Suggest a *'dot-and-cross'* diagram for BaO_2.

Show outer shell electrons only.

[1]

[Total: 10]

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page. The question number(s) must be clearly shown in the margin.

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Oxford Cambridge and RSA

GCE

Chemistry A

Unit **F321:** Atoms, Bonds and Groups

Advanced Subsidiary GCE

Mark Scheme for June 2014

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All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

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These are the annotations, (including abbreviations), including those used in scoris, which are used when marking

Annotation	Meaning
BP	Blank Page – this annotation **must** be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
BOD	Benefit of doubt given
CON	Contradiction
	Incorrect response
ECF	Error carried forward
I	Ignore
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error
SF	Error in number of significant figures
	Correct response
SEEN	Noted but no credit given
REP	Repeat

Subject-specific Marking Instructions

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

All questions must be annotated with a tick placed close to where the mark is given but **NOT** obscuring the text (please refer to Scoris Annotations document from your Team Leader).

Additional pages/objects: You **must** annotate the additional pages (before Question 1) and the additional objects for each script you mark. If no credit is to be awarded for the additional object, please use a suitable annotation (either BP for blank page or SEEN).

ECF should also be used in the following questions where applicable**: 2a, 3b, 3c, 3d, 5cii, 6b**.

The following questions should be fully annotated with ticks, crosses and other relevant annotations to show where marks have been awarded in the body of the text: **4aii, 4d, 5a**

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Question			Answer	Mark	Guidance
1	(a)		period = 5 **AND** block = p ✓	1	
1	(b)	(i)	**Atom(s)** of an element **AND** with different numbers of neutrons (and with different masses) ✓	1	**ALLOW** for '**atoms** of an element': **Atoms** of the same element **OR** **Atoms** with the same number of protons **OR** **Atoms** with the same atomic number **IGNORE** different relative atomic masses **IGNORE** different mass number **IGNORE** same number of electrons **DO NOT ALLOW** different number of electrons **DO NOT ALLOW** 'atoms of elements' for 'atoms of an element' **DO NOT ALLOW** 'an element with different numbers of neutrons) (ie atom(s) is essential)
1	(b)	(ii)	same number of electrons in outer shell **OR** same electron configuration **OR** electron structure ✓	1	**IGNORE** same number of protons **IGNORE** same number of electrons **IGNORE** they are the same element
1	(b)	(iii)	51p 70n 51e ✓	1	

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Question			Answer	Mark	Guidance
1	(c)	(i)	The (weighted) mean **mass** of an **atom** (of an element) **OR** The (weighted) average **mass** of an **atom** (of an element) ✓ compared with 1/12th (the mass) ✓ of (one atom of) carbon-12 ✓	3	**ALLOW** average atomic mass **DO NOT ALLOW** mean mass of an element **ALLOW** mean mass of isotope**s OR** average mass of isotope**s** **DO NOT ALLOW** the singular 'isotope' For second **AND** third marking points **ALLOW** compared with (the mass of) carbon-12 which is 12 For three marks; **ALLOW** mass of **one mole** of **atoms** compared to 1/12th (mass of) **one mole OR** 12**g** of carbon **OR** **ALLOW** $\frac{\text{mass of one mole of atoms}}{\text{1/12th mass of one mole OR 12g of carbon-12}}$
1	(c)	(ii)	123 ✓	1	**ALLOW** ^{123}Sb **OR** Sb-123 **OR** antimony-123 **ALLOW** 123.0 **IGNORE** working
1	(d)	(i)	(Trigonal) Pyramidal ✓ (Sb has) three bonding pairs **AND** one lone pair of electrons ✓ **Pairs** of electrons repel ✓	3	**ALLOW** alternative phrases/words to repel eg 'push apart' **ALLOW** lone pairs repel more than bonding pairs **ALLOW** bonds for bonded pairs **ALLOW** lp and bp **IGNORE** electrons repel **DO NOT ALLOW** atoms repel

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Question			Answer	Mark	Guidance
1	(d)	(ii)	There is a difference in electronegativities (between Sb and C*l*) **OR** (Sb-Cl) bonds are polar **OR** have a dipole **OR** Dipoles seen on the diagram ✓ The molecule is not symmetrical **AND** dipoles do not cancel ✓	**2**	**ALLOW** Because C*l* is more electronegative (than Sb) OR Because Sb is more electronegative (than C*l*) **ALLOW** description that electrons are drawn along a covalent bond **IGNORE** single δ+ or single δ- for dipole **IGNORE** diagram if M1 awarded in text **ALLOW** partial charges do not cancel **IGNORE** references to lone pair causing dipoles
			Total	**13**	

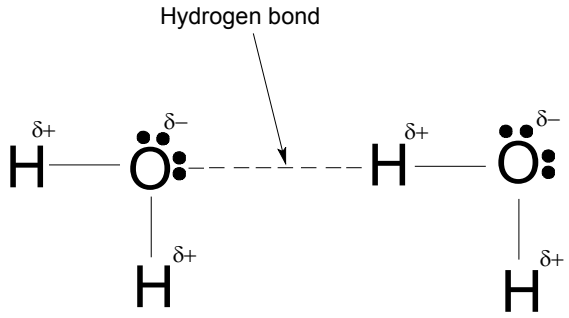
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Question			Answer	Mark	Guidance
2	(a)		FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = CH_4N_2O award 2 marks C H N O 20.00/12.0 6.67/1.0 46.67/14.0 26.66/16.0 **OR** 1.67 6.67 3.33 1.67 ratio of mol ✓ to give CH_4N_2O ✓	2	**ALLOW** 1.66 for C **OR** 1.66 for O **IGNORE** Significant figures beyond the 3rd significant figure. (eg **ALLOW** 3.3335 for N **OR** 1.666 for C) **ALLOW** ECF from incorrectly calculated ratio of mol, **DO NOT ALLOW** ECF from using an atomic number **OR** any original sums inverted (eg 12.00/20.00) **ALLOW** any order of atoms
2	(b)		NH_4^+ ✓ NO_3^- ✓	2	Mark incorrect ions first
2	(c)	(i)	H_3PO_4 ✓	1	**ALLOW** formula if seen as reactant in an equation **IGNORE** name
2	(c)	(ii)	Calcium oxide **OR** calcium hydroxide **OR** calcium carbonate ✓	1	**IGNORE** formulae **IGNORE** lime, quicklime and limestone
			Total	6	

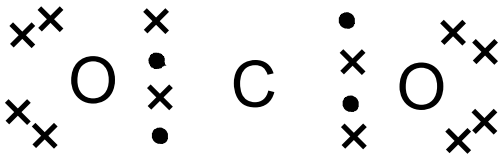
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Question			Answer	Mark	Guidance
3	(a)		Oxidised **AND** because aluminium has lost (three) electron**s** ✓	1	**ALLOW** 'donated' for 'lost' **IGNORE** where electrons are transferred to **IGNORE** $Al \rightarrow Al^{3+} + 3e^-$ **DO NOT ALLOW** 'an electron' or incorrect number of electrons
	(b)		FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 2.88 dm^3 award 2 marks Mol of H_2 = 0.12 ✓ Volume of H_2 = 0.12 x 24.0 = 2.88 dm^3 ✓	2	ALLOW ECF from incorrectly calculated moles of H_2 0.08 x 24 = 1.92 gets 1 mark
	(c)		FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 10.7 g award 2 marks Correctly calculates molar mass of $AlCl_3$ = 133.5 g ✓ Mass of $AlCl_3$ formed = 0.0800 x 133.5 = 10.7 (g) ✓	2	If there is an alternative answer, check to see if there is any ECF credit possible using working below **ALLOW** ECF for incorrect molar mass of $AlCl_3$ multiplied by 0.0800 and correctly rounded to 3 significant figures
	(d)		FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 200(.0) cm^3 award 2 marks Correctly calculates moles of HCl needed = 0.0800 x 3 = 0.24(0) mol ✓ Volume of HCl = 0.24(0) x 1000/1.2 = 200 cm^3 ✓	2	If there is an alternative answer, check to see if there is any ECF credit possible using working below **ALLOW** ECF for incorrect mol of HCl x 1000/1.20 **ALLOW** 66.7 (66.67 or 66.667 etc) for 1 mark **DO NOT ALLOW** 66.6 (66.66 or 66.666 etc)
			Total	7	

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Question			Answer	Mark	Guidance
4	(a)	(i)	*The Dipole Mark* At least one $H^{\delta+}$ **AND** one $O^{\delta-}$ shown correctly on each water molecule (see diagram) ✓  *The Hydrogen bonding Mark* **One** Hydrogen bond between H in one water molecule and a lone pair of O in an adjacent water molecule ✓	2	**DO NOT ALLOW** $H^{\delta-}$ **OR** $O^{\delta+}$ **IGNORE** lone pairs for first marking point All Hydrogen bonds must hit a lone pair Hydrogen bond does NOT need to be labelled but it must be different from the covalent bond if it is not labelled **ALLOW** H-bond as label **ALLOW** only one lone pair on O atom **ALLOW** additional, correctly drawn Hydrogen bonded water molecules with correct dipoles **DO NOT ALLOW** more than two lone pairs on O atom

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Question			Answer	Mark	Guidance
4	(a)	(ii)	*Property 1* Ice is less dense than water ✓ *Explanation 1* The molecules in ice are held apart by hydrogen bonds ✓ **OR** ice has an open lattice **OR** structure *Property 2* Ice has a relatively high melting point ✓ *Explanation 2* Hydrogen bonds are relatively strong OR Hydrogen bonds are stronger (than other intermolecular attractions or forces) OR More energy is needed to overcome hydrogen bonding	4	**ALLOW** ice floats (on water) **ALLOW** ice contracts when it melts **ALLOW** ice (water) has a higher melting point than expected **OR** predicted **ALLOW** other expressions which convey that the melting point is anomalously high eg 'Ice has an unusually high melting point' **IGNORE** boiling point **IGNORE** the following unqualified statements 'Ice has a higher melting point' or 'Ice has a high melting point' **IGNORE** references to surface tension as a property **IGNORE** explanations of surface tension **ALLOW** hydrogen bonds are the strongest intermolecular attraction or force **DO NOT ALLOW** 'hydrogen bonds are strong' but **ALLOW** this as part of a qualified statement (eg 'hydrogen bonds are strong compared with weak van der Waals forces')
4	(b)		 '*dot-and-cross*' of CO_2 ✓	1	Lone pairs on O must be seen Lone pairs may be seen as 4 individual electrons **ALLOW** correct use of three different symbols

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Question			Answer	Mark	Guidance
4	(c)		Giant covalent (lattice) ✓	1	**ALLOW** 'Giant lattice with covalent bonds' **ALLOW** 'Giant covalent bonds' **IGNORE** ' Giant molecular' or 'macromolecular' **DO NOT ALLOW** 'Covalent bonds between molecules'
4	(d)		*Conductivity of Na mark* M1: Sodium conducts in the solid and molten states ✓ *Reason for conductivity of Na mark* M2: Sodium has delocalised electrons (in both solid and liquid state) ✓ *Conductivity of Na_2O mark* M3: Na_2O conducts when molten and not when solid ✓ *Reason for conductivity of Na_2O marks* M4: Molten Na_2O has **ions** which are mobile ✓ M5: Solid Na_2O has **ions** which are fixed (in position) **OR ions** are held (in position) **OR ions** are not mobile **AND** in an (ionic) lattice **OR** structure ✓	5	Quality of written communication 'delocalis(z)ed spelled correctly once and used in context for second marking point **ALLOW** 'carries charge' for conducts for M1 and M3 **IGNORE** 'charge carriers' for electrons **OR** ions for M2, M4 and M5 **DO NOT ALLOW** M2 if incorrect bonding is seen for Na **DO NOT ALLOW** ions move for solid Na for M2 **IGNORE** ions move for molten Na for M2 **ALLOW** solid Na_2O is a poor conductor for M3 **IGNORE** references to aqueous Na_2O for M3 **IGNORE** references to aqueous Na_2O for M4 **IGNORE** 'delocalised ions' **OR** 'free ions' for 'mobile ions' for M4 **DO NOT ALLOW** M4 **AND** M5 if incorrect bonding is seen in Na_2O **DO NOT ALLOW** any mention of electrons moving for M4 **DO NOT ALLOW** suggestion that it is only positive or only negative ions move for M4 **IGNORE** 'there are no delocalised electrons' for M5 **ALLOW** first and second statements of M5 to be unlinked in separate sentences **ALLOW** 'ions fixed in position by ionic bonds' for M5
			Total	13	

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Question			Answer	Mark	Guidance
5	(a)		M1 *Trend **AND** nuclear charge mark* (from Li to F) atomic radius decreases **AND** nuclear charge increases or number of protons increases✓ M2 *same shell/shielding mark* (outer) electrons are in same shell **OR** (outer) electrons experience similar or same shielding ✓ **OR** same number of shells M3 *nuclear attraction mark* Greater **nuclear** attraction on (outer) **electrons** or **shells** **OR** (Outer) **electrons** or **shells** are attracted more strongly to the **nucleus** ✓	3	**ALLOW ORA** throughout if it is clear that the Period is being crossed right to left **ALLOW** 'proton number increases' **IGNORE** 'atomic number increases' **IGNORE** 'nucleus gets bigger' **IGNORE** 'effective nuclear charge increases' **DO NOT ALLOW** 'charge increases' without reference to nuclear' **IGNORE** there is shielding **DO NOT ALLOW** sub-shells **OR** orbitals **DO NOT ALLOW** 'electrons are at a similar distance' This will also contradict M1 **ALLOW** 'there is no change in shielding' **IGNORE** 'shielding has no effect' **DO NOT ALLOW** 'there is no shielding' Quality of written communication 'nucleus' **OR** 'nuclear' spelled correctly once and used in context for third marking point **ALLOW** pull for attraction **IGNORE** for M3, 'electrons are pulled closer to nucleus' as this is a re-statement of the trend mark. **DO NOT ALLOW** 'greater nuclear charge' for 'greater nuclear attraction' for M3

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Question			Answer	Mark	Guidance
5	(b)	(i)	$(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6$ ✓	1	**ALLOW** ... $4s^2\ 3d^{10}4p^6$ **ALLOW** subscripts **AND** 3D **IGNORE** $1s^2$ seen twice
5	(b)	(ii)	Cream **AND** precipitate ✓	1	**ALLOW** solid **OR** ppt for precipitate **IGNORE** 'does not dissolve' OR 'partially dissolves'
5	(b)	(iii)	$Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$ ✓	1	Equation **AND** state symbols required
5	(c)	(i)	***Equation*** $2NaOH + Cl_2 \rightarrow NaCl + NaClO + H_2O$ ✓ ***Conditions*** cold **AND** dilute (sodium hydroxide) ✓	2	**ALLOW** correct multiples **IGNORE** state symbols **ALLOW** room temperature OR ≤ 20^OC for cold

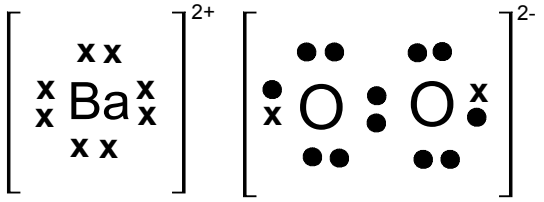
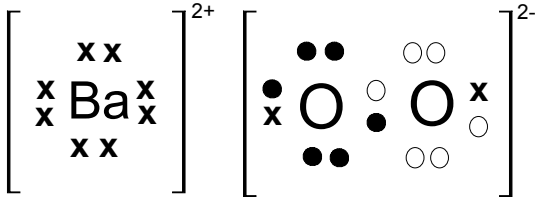
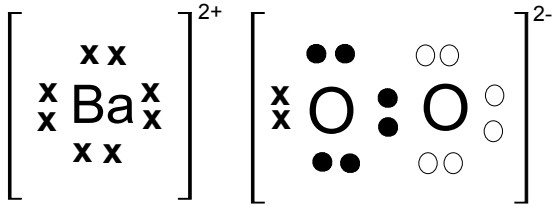
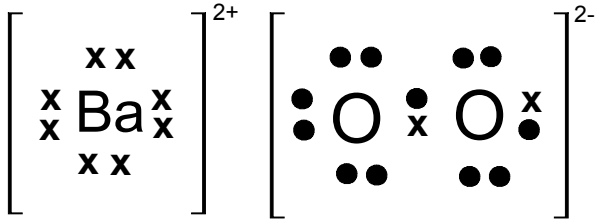
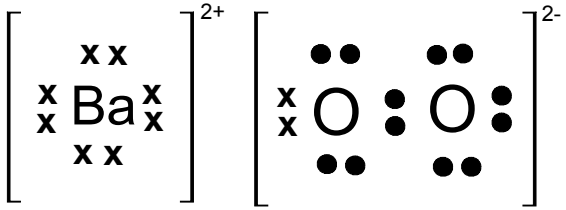
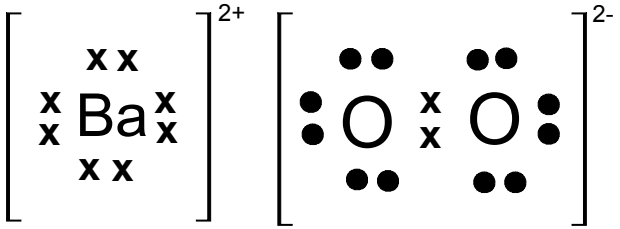
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Question			Answer	Mark	Guidance
(5)	(c)	(ii)	*Definition of disproportionation mark* M1 (Disproportionation) is the (simultaneous) oxidation and reduction of the same element (in the same redox reaction) ✓ M2 Assigning of oxidation numbers Cl in Cl_2 is 0 **AND** Cl in NaCl is -1 **AND** Cl in $NaClO_3$ is +5 ✓ M3 Chlorine has been oxidised from 0 to +5 AND Chlorine has been reduced from 0 to –1 ✓ 'Chlorine has been oxidised from 0 in Cl_2 to +5 in $NaClO_3$ and chlorine has been reduced from 0 in Cl_2 to -1 in NaCl' would secure M2 and M3 $3Cl_2 + 6NaOH \rightarrow 5NaCl + NaClO_3 + 3H_2O$ 0 -1 +5 reduction oxidation This diagram, along with a correct definition, would secure all three marks.	3	**ALLOW** 'an element' OR 'a species' for 'the same element' Assume 'it' means disproportionation M1 can be awarded for 'chlorine is oxidised and reduced **and** this is disproportionation' **ALLOW** oxidation numbers written above the equation if not seen in the text but **IGNORE** oxidation numbers written above the equation if seen in the text **ALLOW** 1– **AND** 5 **AND** 5+ **DO NOT ALLOW** chloride in place of chlorine except for NaCl **DO NOT ALLOW** Cl^- in NaCl AND Cl^{5+} in $NaClO_3$ (ie do not allow ionic charges for oxidation numbers) **ALLOW** Cl **OR** Cl_2 for chlorine **DO NOT ALLOW** M2 if incorrect oxidation numbers of other elements are seen in the text eg H = +2 **ALLOW ECF** for third marks if ONE incorrect oxidation number is assigned but directional changes are correct eg Cl = 0 and -1 and +3 instead 0 and -1 and +5 **DO NOT ALLOW** ECF if two oxidation numbers are incorrectly assigned **IGNORE** references to electron loss/gain If oxidation numbers are correct ALLOW third mark for: chlorine is oxidised to form $NaClO_3$ **AND** chlorine is reduced to form NaCl
			Total	**11**	

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Question			Answer	Mark	Guidance
6	(a)	(i)	$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ ✓	1	
6	(a)	(ii)	$BaCO_3$ **OR** $RaCO_3$ ✓	1	**ALLOW** formula if seen as reactant in an equation **IGNORE** name
6	(b)		FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = $SrCl_2 \cdot 2H_2O$ award 3 marks M1 Correctly calculates Mol of $SrCl_2 \cdot 6H_2O$ = (5.332 / 266.6) = 0.02 mol ✓ M2 Correctly calculates Mol of water given off [(5.332 – 3.892)/18] = 0.08 mol ✓ M3 Correctly calculates 0.08/0.02 = 4 mol of water lost from one mol of $SrCl_2 \cdot 6H_2O$ Therefore Answer = $SrCl_2 \cdot 2H_2O$ ✓	3	**Allow alternative methods** **eg** M1 Correctly calculates mol of $SrCl_2 \cdot 6H_2O$ as 5.332/266.6 = 0.02(00) mol **DO NOT ALLOW** M1 if a second mass is divided by 266.6 M2 Correctly calculates molar mass of partially hydrated product as 3.892/ 0.02(00) = 194.6 M3 Correctly calculates mass of H_2O present as 194.6 – 158.6 = 36.0 **AND** product is $SrCl_2 \cdot 2H_2O$ **ALLOW** ECF for the third mark for showing 158.6 taken from an incorrect stated molar mass leading to an ECF formula **OR** **ALLOW** 266.6 – 194.6 = 72.0 to find amount of water lost
6	(c)	(i)	**Reaction 1:** $Ba + 2H_2O \rightarrow Ba(OH)_2 + H_2$ ✓ **Reaction 2:** $Ba_3N_2 + 6H_2O \rightarrow 3Ba(OH)_2 + 2NH_3$ Correct products ✓ Balancing ✓	3	Ignore state symbols
6	(c)	(ii)	Giant ionic (lattice) ✓	1	**ALLOW** 'Giant lattice with ionic bonds' **ALLOW** 'Giant ionic bonds' **DO NOT ALLOW** 'atoms or molecules or dipoles'

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Question	Answer	Mark	Guidance
(iii)		1	Ba must have a 2+ charge Ba can be with or without octet. **IGNORE** lack of charge on O_2^{2-} ion
	OR		
			O_2^{2-} ion to have 12 electrons belonging to O atoms + 2 other electrons of another symbol. The 2 other electrons must match Ba if Ba has an octet. If O electrons are shown as 6 of one symbol and 6 of another, each O must have six electrons of the same symbol
	OR		
			**ALLOW**
	OR		
			**OR**
			
	Total	**10**	

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RECOGNISING ACHIEVEMENT

Thursday 23 May 2013 – Morning

AS GCE CHEMISTRY A

F321/01 Atoms, Bonds and Groups

Candidates answer on the Question Paper.

OCR supplied materials:
- *Data Sheet for Chemistry A* (inserted)

Other materials required:
- Scientific calculator

Duration: 1 hour

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F3146006133

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The Insert will be found in the centre of this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
-  Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry A* 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**.
- This document consists of **16** pages. Any blank pages are indicated.

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Answer **all** the questions.

1 Silicon and potassium are two elements found in the Earth's crust.

(a) Silicon and potassium both exist as several isotopes.

(i) Define the term *relative isotopic mass.*

.....

.....

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

(ii) Complete the table below for an atom and an ion of two different isotopes of potassium.

	Protons	**Neutrons**	**Electrons**
^{39}K	.....	.....	19
.....	.....	22	18

[2]

(b) Complete the electron configuration of a silicon atom.

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

(c) **(i)** Silicon reacts with chlorine to form molecules of silicon tetrachloride, $SiCl_4$.

How many molecules are present in 8.505 g of $SiCl_4$?

answer = ... molecules **[3]**

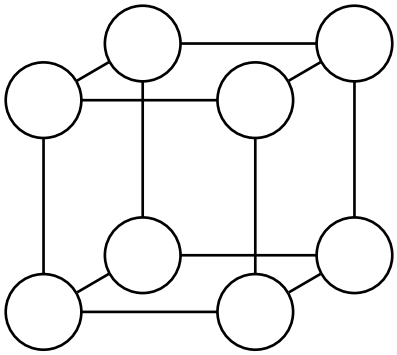
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(ii) Potassium reacts with chlorine to form an ionic lattice of potassium chloride, KC*l*.

A diagram of part of the potassium chloride lattice is shown below.

Add labels to each circle in the diagram to show the particles present in the lattice. The diagram assumes all particles have the same size.



[2]

[Total: 10]

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2 Hydrated aluminium sulfate, $Al_2(SO_4)_3 \bullet \boldsymbol{x}H_2O$, and chlorine, Cl_2, are used in water treatment.

(a) A student attempts to prepare hydrated aluminium sulfate by the following method.

- The student heats dilute sulfuric acid with an excess of solid aluminium oxide.
- The student filters off the excess aluminium oxide to obtain a colourless solution of $Al_2(SO_4)_3$.

(i) State the formulae of the two **main** ions present in the solution of $Al_2(SO_4)_3$.

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

(ii) Write an equation for the reaction of aluminium oxide, Al_2O_3, with sulfuric acid.

Include state symbols.

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

(iii) What does '$\bullet \boldsymbol{x}H_2O$' represent in the formula $Al_2(SO_4)_3 \bullet \boldsymbol{x}H_2O$?

.....

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

(iv) The student heats 12.606 g of $Al_2(SO_4)_3 \bullet \boldsymbol{x}H_2O$ crystals to constant mass.

The anhydrous aluminium sulfate formed has a mass of 6.846 g.

Use the student's results to calculate the value of ***x***.

The molar mass of $Al_2(SO_4)_3 = 342.3\,g\,mol^{-1}$.

x = ... **[3]**

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(b) A student tests chlorine gas with damp blue litmus paper. The litmus paper first turns a red colour and is then bleached. A reaction takes place between chlorine and water in the damp litmus paper.

(i) Write the equation for the reaction between chlorine and water.

Explain why the damp litmus paper turns a red colour as a result of this reaction.

.....

.....

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

(ii) Bleach is made by reacting chlorine with cold dilute aqueous sodium hydroxide.

Suggest the formula of the **ion** responsible for bleaching.

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

[Total: 11]

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3 The hydrides of Group 5 elements all exist as gases at room temperature.

(a) Phosphine gas, PH_3, can be prepared by adding phosphorus, P_4, to warm concentrated aqueous sodium hydroxide as shown in the equation below.

$$P_4(s) + 3NaOH(aq) + 3H_2O(l) \longrightarrow PH_3(g) + 3NaH_2PO_2(aq)$$

(i) Using oxidation numbers, explain why this is a disproportionation reaction.

.....

.....

.....

.....

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

(ii) A chemist reacts 1.86 g of P_4 with excess NaOH(aq).

Calculate the volume of phosphine gas, in cm^3, produced at room temperature and pressure, RTP.

volume of phosphine gas = ... cm^3 **[2]**

(b) Phosphine gas burns in air to form an oxide of phosphorus, P_4O_{10}, and water.

Write the equation for this reaction.

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

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(c) Phosphoric acid, H_3PO_4, can be made by reacting P_4O_{10} with water.

Sodium phosphate, Na_3PO_4, is a salt that can be prepared by reacting H_3PO_4 with sodium hydroxide, NaOH.

A student prepared a solution of Na_3PO_4 by reacting 15.0 cm^3 of 0.100 mol dm^{-3} H_3PO_4 with 0.200 mol dm^{-3} NaOH.

(i) Why is Na_3PO_4 described as a salt of H_3PO_4?

.....

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

(ii) Calculate the amount, in moles, of H_3PO_4 in 15.0 cm^3 of 0.100 mol dm^{-3} H_3PO_4.

amount = ... mol **[1]**

(iii) The equation for the preparation of Na_3PO_4 from NaOH and H_3PO_4 is shown below.

$$3NaOH(aq) + H_3PO_4(aq) \rightarrow Na_3PO_4(aq) + 3H_2O(l)$$

Calculate the volume of 0.200 mol dm^{-3} NaOH that reacts exactly with 15.0 cm^3 of 0.100 mol dm^{-3} H_3PO_4.

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

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(d) Ammonia, NH_3, is another gaseous Group 5 hydride.

NH_3 and PH_3 are both simple molecules. The boiling points of NH_3 and PH_3 are shown in the table below.

Group 5 hydride	Boiling point / °C
NH_3	–33
PH_3	–88

(i) Complete the table below to show the main intermolecular forces present in NH_3 and PH_3.

Group 5 hydride	Main intermolecular force
NH_3	
PH_3	

[2]

(ii) Suggest why PH_3 has a lower boiling point than NH_3.

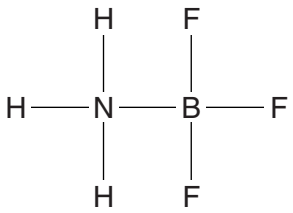
.....

.....

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

(e) NH_3 reacts with molecules of BF_3 to form H_3NBF_3, shown below.

One of the bonds in H_3NBF_3 is a dative covalent bond.



(i) A covalent bond is a shared pair of electrons.

What is a *dative* covalent bond?

.....

.....

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

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(ii) Draw a '*dot-and-cross*' diagram to show the bonding in H_3NBF_3.

Label the dative covalent bond in your diagram.

Show **outer** electrons only.

[2]

(iii) The F–B–F bond angle in BF_3 is different from the F–B–F bond angle in H_3NBF_3.

Complete the table to predict the F–B–F bond angles in BF_3 and in H_3NBF_3.

Molecule	**F–B–F bond angle / °**
BF_3	
H_3NBF_3	

[2]

(iv) The H–N–H bond angle in NH_3 is 107°. A student predicted that the H–N–H bond angle in H_3NBF_3 is larger.

Explain why the student might expect the H–N–H bond angle to be larger in H_3NBF_3 than in NH_3.

.....

.....

.....

.....

.....

.....

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

[Total: 20]

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4 Group 2 elements react with halogens.

(a) Describe and explain the trend in reactivity of Group 2 elements with chlorine as the group is descended.



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

.....

.....

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..... **[5]**

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(b) A student was provided with an aqueous solution of calcium iodide.

The student carried out a chemical test to show that the solution contained iodide ions. In this test, a precipitation reaction took place.

(i) State the reagent that the student would need to add to the solution of calcium iodide.

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

(ii) What observation would show that the solution contained iodide ions?

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

(iii) Write an ionic equation, including state symbols, for the reaction that took place.

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

(iv) The student is provided with an aqueous solution of calcium bromide that is contaminated with calcium iodide.

The student carries out the same chemical test but this time needs to add a second reagent to show that iodide ions are present.

State the second reagent that the student would need to add.

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

[Total: 9]

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5 Periodicity is a repeating pattern across different periods.

(a) First ionisation energy shows a trend across Period 2.

The first ionisation energies of lithium, carbon and fluorine are shown in **Table 5.1** below.

Element	Lithium	Carbon	Fluorine
First ionisation energy / kJ mol^{-1}	520	1086	1681

Table 5.1

(i) Explain the trend across Period 2 shown in **Table 5.1**.

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

.....

.....

.....

.....

.....

.....

.....

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

(ii) Solid carbon exists in two forms, diamond and graphite.

Explain why it is unnecessary to refer to carbon as either diamond or graphite in **Table 5.1**.

.....

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

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(b) Lithium, carbon (in the form of diamond) and fluorine have very different melting points.

These differences in melting points are the result of different types of structure and different forces or bonds between the particles in the structures.

Part of the table below has been filled in.

Complete the table below.

	Lithium	**Carbon (diamond)**	**Fluorine**
Melting point/°C	181	3550	–220
Structure	Giant		Simple
Force or bond overcome on melting	Metallic bond		
Particles between which the force or bond is acting			

[6]

[Total: 10]

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margins.

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GCE

Chemistry A

Advanced Subsidiary GCE

Unit **F321:** Atoms, Bonds and Groups

Mark Scheme for June 2013

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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1. **Annotations**

Annotation	Meaning
BOD	Benefit of doubt given
CON	Contradiction
	Incorrect response
ECF	Error carried forward
I	Ignore
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error
SF	Error in number of significant figures
	Correct response
SEEN	Noted but no credit given
REP	Repeat

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2. **Subject-specific Marking Instructions**

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

All questions must be annotated with a tick where the mark is given.

Additional pages/objects: You **must** annotate the additional pages (before Question 1) and the additional objects for each script you mark. If no credit is to be awarded for the additional object, please use a suitable annotation (either ^ or SEEN).

The following questions should be fully annotated with ticks, crosses and other relevant annotations to show where marks have been awarded in the body of the text:

3ai

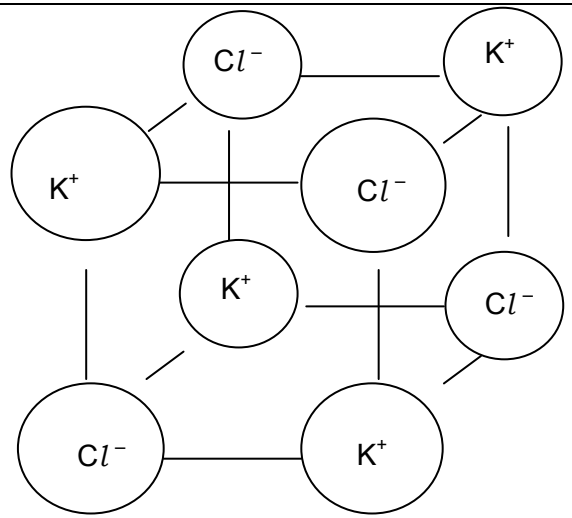
4a

5ai

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Question			Answer	Marks	Guidance
1	(a)	(i)	**Mass** of the **isotope** compared to 1/12th **OR** **mass** of the **atom** compared to 1/12th ✓ (the mass of an atom of) ^{12}C ✓	2	**ALLOW** for ^{12}C: carbon-12 **OR** C-12 **OR** C 12 **OR** 12C **ALLOW** mass of a **mole** of the isotope **OR** mass of a mole of atoms compared to 1/12th the mass of **mole** or 12 **g** of ^{12}C for two marks **ALLOW** mass of the isotope or mass of the atom compared to ^{12}C which has a mass of 12(.0) for two marks **ALLOW** one mark for responses which have individual atoms compared to one mole of 12C and vice versa eg mass of the isotope or mass of the atom compared to ^{12}C which has a mass of 12(.0) **g** eg mass of an atom compared to 1/12th mass of one mole of ^{12}C eg mass of one mole of atoms compared to 1/12th the mass of an atom of 12C **ALLOW** 2 marks for responses expressed as a fraction eg $\frac{\text{mass of the isotope}}{\text{mass of 1/12th mass of } ^{12}C}$ **IGNORE** (weighted) mean **OR** average **DO NOT ALLOW** mass of element or mass of ion
		(ii)	19p and 20n ✓ $^{41}K^{+}$ and 19p ✓	2	Mark by row **ALLOW** 41K+
	(b)		$(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^2$ ✓	1	**ALLOW** $1s^2$ repeated **ALLOW** subscripts **AND** upper case etc

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Question			Answer	Marks	Guidance
1	(c)	(i)	**First check the answer on the answer line.** **If answer =** 3.01 x 10^{22} award 3 marks 170.1 ✓ (**ALLOW** in working shown as 28.1 + 35.5 x 4) Correctly calculates amount of molecules 8.505 / 170.1 = 0.05(00) mol ✓ Correctly calculates number of molecules 0.05 x 6.02 x 10^{23} = 3.01 x 10^{22} ✓	3	**ALLOW** 0.301 x 10^{23} for three marks If there is an alternative answer, check to see if there is any ECF credit possible using working below. **ALLOW** ECF from incorrect molar mass of $SiCl_4$ **ALLOW** 0.05(00) (mol) for two marks **ALLOW** ECF for incorrect number of mol of $SiCl_4$ **ALLOW** calculator value or rounding to 3 significant figures or more **BUT IGNORE** 'trailing' zeroes, eg 0.200 allowed as 0.2. **DO NOT ALLOW** any marks for: 8.505 x 6.02 x 10^{23} = 5.12 x 10^{24}
		(ii)	 4 K and 4 C*l* correctly arranged ✓ 4 K^+ and 4 Cl^- correctly arranged ✓	2	**ALLOW** the structure with **ALL** Cl^- and K^+ transposed **ALLOW** labels if seen outside circles but linked with an arrow eg K^+ → ○
			Total	**10**	

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Question			Answer	Marks	Guidance
2	(a)	(i)	Al^{3+} ✓ SO_4^{2-} ✓	2	
		(ii)	$Al_2O_3(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 3H_2O(l)$ Correct species **AND** correctly balanced ✓ state symbols on **correct** species ✓	2	**ALLOW** multiples
		(iii)	(The number of) water(s) of crystallisation ✓	1	**IGNORE** hydrated **OR** hydrous **OR** 'contains water'
		(iv)	**First check the answer on the answer line.** **If answer** = 16, award 3 marks Correctly calculates amount of $Al_2(SO_4)_3$: 6.846 / 342.3 = 0.02(00) mol ✓ Correctly calculates amount of H_2O: 5.760 / 18.0 = 0.32(0) mol ✓ Correctly calculates whole number ratio of mol of H_2O: $Al_2(SO_4)_3$ to give ***x*** = 16 ✓	3	If there is an alternative answer, check to see if there is any ECF credit possible using working below **ALLOW** as ECF from 12.606/342.3 = 0.0368(273) **AND** 0.32/0.0368(273) To give ***x*** = 9 for two marks **ALLOW** calculator value or rounding to 2 significant figures or more **BUT IGNORE** 'trailing' zeroes, eg 0.200 allowed as 0.2. **ALLOW** ECF for calculation of correctly rounded **whole number** value of H_2O from incorrect mol of H_2O and / or incorrect mol of $Al_2(SO_4)_3$ **BUT** ***x*** must be a whole number **ALLOW** alternative method Mol of $Al_2(SO_4)_3$: 6.846 / 342.3 = 0.02(00) mol (first mark) Molar mass of $Al_2(SO_4)_3 \cdot xH_2O$: 12.606 / 0.02(00) = 630.3 g mol^{-1} (second mark) Mass of water per mol = 630.3 – 342.3 = 288 **AND** 288/18 to give ***x*** = 16 (third mark)

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Question			Answer	Marks	Guidance
2	(b)	(i)	$Cl_2 + H_2O \rightarrow HCl + HClO$ ✓ H^+ ions are released **OR** HC*l* is acidic **OR** HC*l*O is acidic ✓	2	**ALLOW** HOC*l* **ALLOW** equilibrium sign **IGNORE** state symbols **ALLOW** formulae **OR** names *If correct equation is seen:* **ALLOW** 'product is acidic' **OR** 'acid is produced' **IGNORE** 'the solution is acidic' but **ALLOW** 'the solution formed is acidic' **DO NOT ALLOW** 'chlorine is acidic' ie acidity must be related to the product(s) *If an incorrect equation is seen:* **ALLOW** second mark if H^+ **OR** HC*l* **OR** HC*l*O is given as a product in the equation **AND** is stated as being acidic *If no equation is seen:* **ALLOW** second mark if H^+ **OR** HC*l* **OR** HC*l*O is produced **AND** is stated as being acidic
		(ii)	ClO^- ✓	1	**ALLOW** OCl^-
			Total	**11**	

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Question			Answer	Marks	Guidance
3	(a)	(i)	P in P_4 is 0 **AND** in PH_3 is –3 **AND** in NaH_2PO_2 is (+)1 ✓ Phosphorus has been oxidised (from 0) to +1✓ Phosphorus has been reduced (from 0) to –3 ✓	3	**FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED** **ALLOW** oxidation states written above the equation if not seen in the text BUT **IGNORE** oxidation states written above the equation if seen in the text **ALLOW** 3– **AND** 1+ **DO NOT ALLOW ions** **DO NOT ALLOW** P^{3-} in PH_3 **OR** P^{+} in NaH_2PO_2 **DO NOT ALLOW** phosph**ide** or phosph**ine** or phosphate in place of phosphorus **ALLOW** P or P_4 for phosphorus **ALLOW** ECF for the second and third marks if **ONE** incorrect oxidation number is assigned but directional changes are correct eg P = 0 and –3 and +2 instead of 0 and –3 and +1. **IGNORE** references to electron loss / gain If correct oxidation numbers are seen **ALLOW** second **AND** third marking points for: 'Phosphorus is oxidised to form NaH_2PO_2' **AND** 'Phosphorus is reduced to form PH_3' **IF** neither second and third marks have been awarded **ALLOW** for **ONE** mark: Phosphorus has been both oxidised and reduced **OR** Phosphorus's oxidation number has increased and decreased

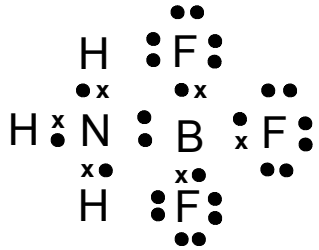
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Question			Answer	Marks	Guidance
3	(a)	(ii)	**First check the answer on the answer line.** **If answer** = 360 (cm^3) award 2 marks Correctly calculates amount of P_4 = 1.86/124.0 = 0.015(0) mol ✓ Correctly calculates volume of PH_3 = 0.015(0) x 24000 = 360 (cm^3) ✓	2	If there is an alternative answer, check to see if there is any ECF credit possible using working below **ALLOW** ECF for wrong amount of P_4 x 24000 for second mark **ALLOW** one mark for (1.86/31.0) x 24000 = 1440 **DO NOT ALLOW** 2nd mark for 1.86 x 24000 = 44640 **ALLOW** calculator value or rounding to 2 significant figures or more **BUT IGNORE** 'trailing' zeroes, eg 0.200 allowed as 0.2.
	(b)		$4PH_3 + 8O_2 \rightarrow P_4O_{10} + 6H_2O$ ✓	1	**ALLOW** correct multiples **IGNORE** state symbols
	(c)	(i)	The hydrogen **ions OR** H^+ **OR** protons (of phosphoric acid) are replaced by sodium **ions OR** Na^+ ✓	1	**ALLOW** Na ions **OR** positive ions replace H ions **OR** metal ions have replaced hydrogen ions **OR** protons **DO NOT ALLOW** Na replaces H. Ions are key in either word or symbol form. **DO NOT ALLOW** incorrect charge on Na ions (eg Na^{2+})
		(ii)	Correctly calculates 0.100 x 15 / 1000 = 1.5(0) x 10^{-3} **OR** 0.0015(0) ✓	1	
		(iii)	22.5 ✓	1	**ALLOW** ECF from (ii) Answer from (ii) x (3/0.2) x 1000
	(d)	(i)	hydrogen bonding ✓ Permanent dipole(–dipole interactions) ✓	2	

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Question			Answer	Marks	Guidance
3	(d)	(ii)	the intermolecular forces are weaker in PH_3 ✓	1	**ALLOW** the energy needed to overcome the intermolecular forces in NH_3 is greater Check table in part (i) **IF** NH_3 = hydrogen bonds **AND** PH_3 = permanent dipoles **OR** van der Waal's forces; **ALLOW** 'Hydrogen Bonds are stronger' **ORA** **IF** NH_3 = permanent dipoles **AND** PH_3 = van der Waal's forces; **ALLOW** 'permanent dipoles are stronger' **ORA** **IF** NH_3 = permanent dipoles **AND** PH_3 = permanent dipoles; **ALLOW** 'permanent dipoles are stronger **in NH_3**' **ORA** **DO NOT ALLOW** PH_3 has weaker vdW's than NH_3 **DO NOT ALLOW** NH_3 has stronger hydrogen bonds than PH_3 **DO NOT ALLOW** implication that covalent bonds are broken
	(e)	(i)	Both electrons have been donated by one atom ✓	1	**ALLOW** 'they' for electrons **IGNORE** elements for atom **DO NOT ALLOW** 'transfer' in place of 'donated' **DO NOT ALLOW** more than one electron pair is donated

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Question			Answer	Marks	Guidance
3	(e)	(ii)	 Correct '*dot-and-cross*' arrangement of B covalently '*dot-and-cross*' bonded to three F atoms, including full octet on F atoms **AND** Correct '*dot-and-cross*' arrangement of N covalently '*dot-and-cross*' bonded to three H atoms ✓ Dative covalent shown between N and B atoms ✓	2	Must be '*dot-and-cross*', but **ALLOW** other symbols for electrons of third and fourth atoms eg ∆, +, o, etc Circles for outer shells are not needed **IGNORE** inner shells **IGNORE** use of charges Non-bonding electrons of F do not need to be seen as pairs **IGNORE** dative-covalent arrows from N to B, but **DO NOT ALLOW** arrow from B to N **DO NOT ALLOW** two separate molecules for first mark **DO NOT ALLOW** dative covalent bond mark if electron pair matches the B electrons ie to be correct the dative pair must be the same symbol as non-bonding electrons on F atoms if only two symbols are used **DO NOT ALLOW** dative covalent bond mark if F atoms have no non-bonding electrons **UNLESS** B has different electron symbol to N or H atoms
		(iii)	BF_3 = 120(◦) ✓ H_3NBF_3 = 109.5(◦) ✓	2	**ALLOW** 109–110(◦) for H_3NBF_3

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Question			Answer	Marks	Guidance
3	(e)	(iv)	(N in) NH_3 has three bonding pairs and one lone pair of electrons ✓ (N in) H_3NBF_3 has **four** bonding pairs (and no lone pairs) of electrons **OR** Lone pair on N now becomes bonding pair ✓ Lone pair of electrons repels **more** than bonding pairs ✓	3	**ALLOW** 'bonds' for 'bonding pairs' **IGNORE** 'electrons repel' **DO NOT ALLOW** 'atoms repel'
			Total	**20**	

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Question			Answer	Marks	Guidance
4	(a)			5	**FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED** 'Down the group' is not required **ORA** throughout
			Reactivity increases (down the group) ✓		**ALLOW** alternative phrases for 'reactivity increases'
			Increasing size mark Atomic radius increases **OR** There are more shells ✓		**ALLOW** 'there are more energy levels' **ALLOW** 'electrons are in higher energy levels' **ALLOW** 'electrons are further from the nucleus' **IGNORE** there are more orbitals **OR** more sub-shells **ALLOW** 'different shell' **OR** 'new shell'
			Increased shielding mark There is **more** shielding ✓		There must be clear comparison ie 'more shielding' **OR** 'increased shielding' **ALLOW** there is **more** electron repulsion from inner shells **DO NOT ALLOW** responses which have no comparative eg 'there is shielding'
			Nuclear attraction (to electron) mark Nuclear attraction (to electron) decreases **OR** (outermost) electrons experience less attraction (to nucleus) **OR** Increased nuclear charge is outweighed by increased shielding/distance ✓		**ALLOW** 'there is less nuclear pull' **OR** 'electrons less tightly held' **IGNORE** there is less effective nuclear charge **IGNORE** 'nuclear charge' for 'nuclear attraction' If question is answered in terms of only Group 7, then **ONLY** marks 2, 3 and 4 can be awarded
			Ease of electron loss mark Easier to remove (outer) electron(s) **OR** Ionisation energy decreases ✓		**ALLOW** easier to oxidise
			Quality of written communication *electron(s)* ***OR*** *ionisation* ***OR*** *ionization* ***OR*** *oxidise* ***OR*** *oxidize spelled correctly at least once for last marking point*		

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Question			Answer	Marks	Guidance
4	(b)	(i)	$AgNO_3(aq)$ **OR** silver nitrate **OR** $AgNO_3$ ✓	1	**ALLOW** $Ag^+(aq)$
		(ii)	Yellow **AND** precipitate ✓	1	**ALLOW** shades of yellow but not creamy yellow **ALLOW** ppt or solid for precipitate
		(iii)	$Ag^+(aq) + I^-(aq) \rightarrow AgI(s)$ ✓	1	**ALLOW** correct multiples
		(iv)	**concentrated** (aqueous) NH_3 ✓	1	
			Total	**9**	

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Question			Answer	Marks	Guidance
5	(a)	(i)	*Nuclear charge mark* (Across the period) number of protons increases **OR** greater nuclear charge ✓ ***Quality of written communication*** *– nuclear* ***OR*** *proton(s)* ***OR*** *nucleus spelled correctly ONCE for the first marking point* *Distance / shielding mark* (Outermost) electrons are in the same shell **OR** (Outermost) electrons experience the same shielding **OR** Atomic radius decreases ✓ *Nuclear attraction (to electron) mark* Greater nuclear attraction (on outermost electrons) **OR** (outer) electrons are attracted more strongly (to the nucleus) ✓	3	**FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED** Comparison should be used for each mark **IGNORE** atomic number increases, but **ALLOW** proton number increases **IGNORE** nucleus gets bigger **IGNORE** 'effective nuclear charge increases' **DO NOT ALLOW** 'charge' increases without reference to nuclear **ALLOW** shielding is similar BUT **IGNORE** 'there is shielding' **DO NOT ALLOW** sub-shells **OR** orbitals **ALLOW** greater nuclear pull for greater nuclear attraction **DO NOT ALLOW** use of greater nuclear charge for greater nuclear attraction for third mark
		(ii)	(Diamond and graphite form) **gaseous atoms** (of carbon when they are ionised) ✓	1	**ALLOW** the **atoms** are in the **gaseous** state

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<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td></td><td>(b)</td><td></td><td>
<table>
<tr><th></th><th>Lithium</th><th>Carbon (diamond)</th><th>Fluorine</th></tr>
<tr><td>Structure</td><td>Giant</td><td>Giant ✓</td><td>Simple</td></tr>
<tr><td>Force or bond overcome on melting</td><td>Metallic bond</td><td>Covalent (bond) ✓</td><td>van der Waals' (forces) OR induced dipoles ✓</td></tr>
<tr><td>Particles between which the force or bond is acting</td><td>Li^+ ions and (delocalised) electrons ✓</td><td>Atoms ✓</td><td>Molecules ✓</td></tr>
</table>
</td><td>6</td><td>ALLOW shared pair of electrons for covalent (bond)

ALLOW vdw for van der Waals'
ALLOW temporary–induced or instantaneous–induced for van der Waals'

ALLOW Positive ions for Li^+ ions
IGNORE 'Lithium ions' but ALLOW 'Positive lithium ions'
DO NOT ALLOW Li^{2+}

IGNORE C and IGNORE F_2
IGNORE diagrams but ALLOW names of particles if seen as a label on a diagram

DO NOT ALLOW implication that covalent bonds are broken in fluorine for the particles mark of fluorine as this implies the particles are atoms</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>10</td><td></td></tr>
</table>

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RECOGNISING ACHIEVEMENT

Thursday 10 January 2013 – Morning

AS GCE CHEMISTRY A

F321/01 Atoms, Bonds and Groups

F3144201133

Candidates answer on the Question Paper.

OCR supplied materials:
- *Data Sheet for Chemistry A* (inserted)

Other materials required:
- Scientific calculator

Duration: 1 hour

F3210 1

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The Insert will be found in the centre of this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
-  Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry A* 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**.
- This document consists of **12** pages. Any blank pages are indicated.

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Answer **all** the questions.

1 Tungsten metal is used in the manufacture of some types of steel.

Tungsten has an atomic number of 74.

(a) Tungsten has many isotopes.

(i) Explain what is meant by *isotopes*.

.....

.....

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

(ii) The mass number of one isotope of tungsten is 184.

Complete the table below to show the atomic structure of this tungsten isotope.

Protons	Neutrons	Electrons

[1]

(iii) What is used as the standard measurement of relative isotopic mass?

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

(b) In the manufacture of tungsten metal, an oxide of tungsten, WO_3, is reacted with hydrogen gas.

$$WO_3(s) + 3H_2(g) \rightarrow W(s) + 3H_2O(g)$$

(i) Using **oxidation numbers**, show what has been oxidised and what has been reduced in this reaction.

oxidised .....

.....

reduced .....

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

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(ii) A chemist reacts 11.59 g of WO_3 with hydrogen gas.

Calculate the volume of hydrogen gas, in dm^3, required to completely react with this mass of WO_3 at room temperature and pressure.

volume of hydrogen gas = ... dm^3 **[3]**

[Total: 8]

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2 Simple molecules are covalently bonded.

(a) State what is meant by the term *covalent bond*.

.....

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

(b) Chemists are able to predict the shape of a simple covalent molecule from the number of electron pairs surrounding the central atom.

(i) Explain how this enables chemists to predict the shape.

.....

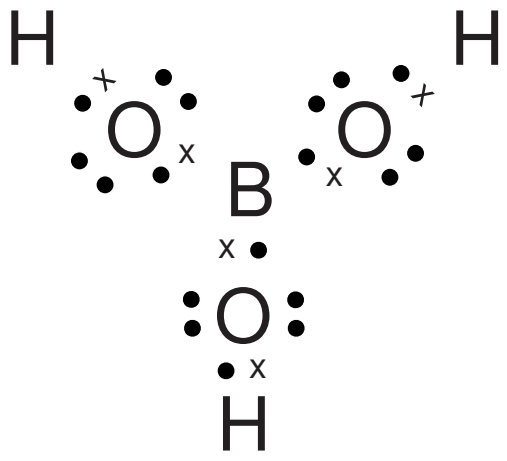
.....

.....

.....

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

(ii) The '*dot-and-cross*' diagram of the simple covalent molecule, H_3BO_3, is shown below.



Predict the O–B–O and B–O–H bond angles in a molecule of H_3BO_3.

O–B–O = ... ° B–O–H = ...° **[2]**

(c) Give an example of a simple covalent molecule which has all bond angles equal to 90°.

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

[Total: 6]

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3 Successive ionisation energies provide evidence for the existence of different shells in atoms.

(a) Define, in words, the term *first ionisation energy*.

.....

.....

.....

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

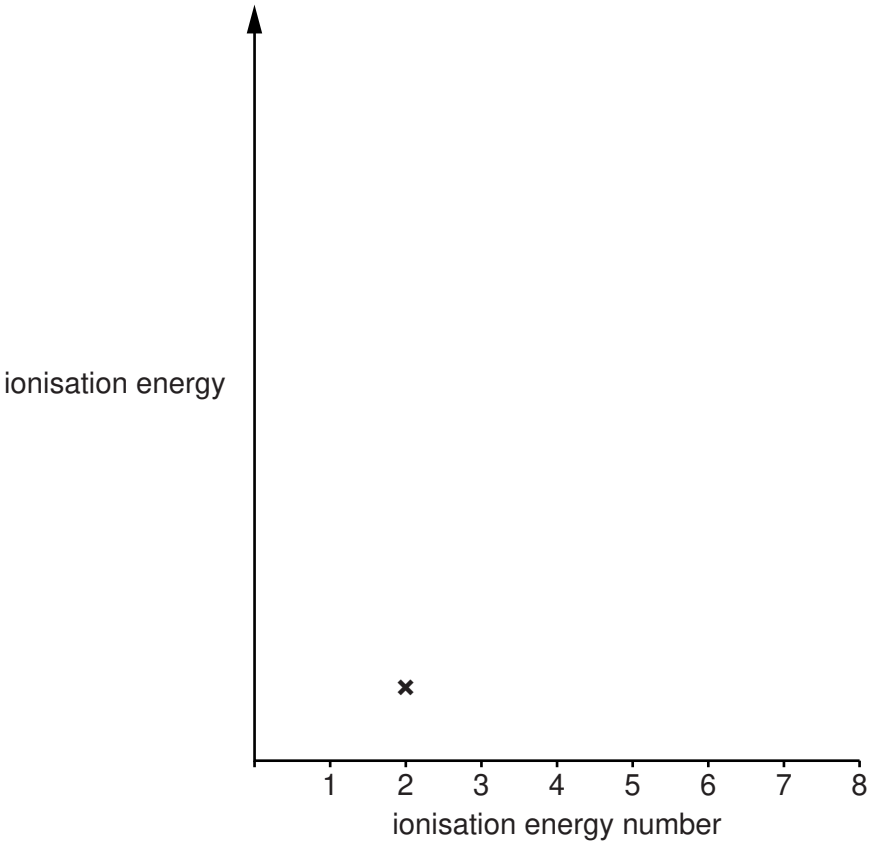
(b) **(i)** Write an equation to represent the **second** ionisation energy of oxygen.

Include state symbols.

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

(ii) On the axes below, add crosses to estimate the successive ionisation energies of oxygen. The second ionisation energy has been added for you.

It is **not** necessary to join your points.



[2]

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(c) The first ionisation energy of oxygen is **less** than the first ionisation energy of fluorine.

Explain why.

.....

.....

.....

.....

.....

.....

.....

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

(d) When oxygen reacts with metals it forms oxide ions.

Write the electron configurations, in terms of sub-shells, of an oxygen atom and an oxide ion.

Hence, explain why this reaction of oxygen is typical of a non-metal.

oxygen atom .....

oxide ion .....

.....

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

(e) Many ions contain oxygen combined with atoms of other elements.

For example, the nitrate(V) ion has the formula NO_3^-.

(i) In the table below, write the formula of the sulfate(IV) ion and the chlorate(III) ion.

Ion	Ionic charge	Formula
Nitrate(V)	1–	NO_3^-
Sulfate(IV)	2–	
Chlorate(III)	1–	

[2]

(ii) Write the formula of aluminium nitrate(V).

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

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(iii) Aluminium nitrate(V) can be made by reacting a base with an acid.

For this reaction, name a suitable base and write the formula of the acid.

name of base .....

formula of the acid ..... **[2]**

[Total: 16]

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4 The Group 2 element barium was first isolated by Sir Humphrey Davy in 1808.

Barium has a giant metallic structure and a melting point of 725 °C.

(a) Describe, with the aid of a labelled diagram, the structure and bonding in barium and explain why barium has a high melting point.

Include the correct charges on the metal particles in your diagram.

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

.....

.....

.....

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

(b) A chemist reacts barium with water. A solution is formed which conducts electricity.

(i) Write the equation for the reaction of barium with water. Include state symbols.

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

(ii) Predict a value for the pH of the resulting solution.

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

(iii) Give the **formula** of the negative ion responsible for the conductivity of the solution formed.

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

(c) Heartburn is a form of indigestion caused by an excess of stomach acid.

State a compound of magnesium that could be used to treat heartburn.

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

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(d) In an experiment, a student makes a solution of strontium chloride, $SrCl_2$, by adding excess dilute hydrochloric acid to strontium carbonate.

(i) Describe what the student would observe and write the equation for the reaction.

observations .....

.....

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

(ii) Draw a '*dot-and-cross*' diagram to show the bonding of strontium chloride.
Show **outer** electrons only.

[2]

(e) In another experiment, a student attempts to make a solution of strontium chloride by adding chlorine water to aqueous strontium bromide.

(i) Describe what the student would observe.

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

(ii) Write the ionic equation for the reaction which takes place.

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

(iii) Chlorine is more reactive than bromine. Explain why.

.....

.....

.....

.....

.....

.....

.....

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

[Total: 18]

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5 Hydrogen chloride is a colourless gas which forms white fumes in moist air.

(a) Molecules of hydrogen chloride, HC*l*, and molecules of fluorine, F_2, contain the same number of electrons. Hydrogen chloride boils at –85 °C and fluorine boils at –188 °C.

Explain why there is a difference in the boiling points of HC*l* and F_2.

In your answer you should refer to the types of force acting between molecules and the relative strength of the forces between the molecules.



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

.....

.....

.....

.....

.....

.....

.....

.....

.....

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

(b) Hydrogen chloride reacts with water to produce an ion with the formula H_3O^+.

An H_3O^+ ion has one dative covalent bond.

Draw a '*dot-and-cross*' diagram to show the bonding in H_3O^+.

Show **outer** electrons only.

[2]

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(c) Borax, $Na_2B_4O_7 \cdot 10H_2O$, can be used to determine the concentration of acids such as dilute hydrochloric acid.

A student prepares 250 cm^3 of a 0.0800 mol dm^{-3} solution of borax in water in a volumetric flask.

Calculate the mass of borax crystals, $Na_2B_4O_7 \cdot 10H_2O$, needed to make up 250 cm^3 of 0.0800 mol dm^{-3} solution.

answer = ... g **[3]**

Question 5 continues on page 12

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(d) The student found that 22.50 cm^3 of 0.0800 mol dm^{-3} $Na_2B_4O_7$ reacted with 25.00 cm^3 of dilute hydrochloric acid.

$$Na_2B_4O_7 + 2HCl + 5H_2O \rightarrow 2NaCl + 4H_3BO_3$$

(i) Calculate the amount, in mol, of $Na_2B_4O_7$ used.

amount = ... mol **[1]**

(ii) Calculate the amount, in mol, of HCl used.

amount = ... mol **[1]**

(iii) Calculate the concentration, in mol dm^{-3}, of the HCl.

concentration = ... mol dm^{-3} **[1]**

[Total: 12]

END OF QUESTION PAPER

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RECOGNISING ACHIEVEMENT

GCE

Chemistry A

Advanced Subsidiary GCE

Unit **F321:** Atoms, Bonds and Groups

Mark Scheme for January 2013

Oxford Cambridge and RSA Examinations

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Annotations

Annotation	Meaning
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Ignore
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error
	Error in number of significant figures
	Correct response

Subject-specific Marking Instructions

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

The following questions should be fully annotated with ticks, crosses, ecf etc to show where marks have been awarded in the body of the text:

3(c), 4(e)(iii) and 5(a)

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<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td>(i)</td><td>Atom(s) of an element

AND

with different numbers of neutrons (and with different masses) ✓</td><td>1</td><td>ALLOW for ‘atoms of an element’:
Atoms of the same element
OR atoms with the same number of protons
OR atoms with the same atomic number

IGNORE ‘different relative atomic masses’
IGNORE different mass number
IGNORE same number of electrons
DO NOT ALLOW different numbers of electrons
DO NOT ALLOW ‘atoms of elements’ for ‘atoms of an element’
DO NOT ALLOW ‘an element with different numbers of neutrons’ (ie atom(s) is essential)</td></tr>
<tr><td></td><td></td><td>(ii)</td><td><table><tr><th>Protons</th><th>Neutrons</th><th>Electrons</th><th></th></tr><tr><td>74</td><td>110</td><td>74</td><td>✓</td></tr></table></td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>(iii)</td><td>^{12}C OR C-12 OR carbon 12 OR carbon-12 ✓</td><td>1</td><td>IGNORE 1/12th AND amu</td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td>(Oxidised):
H (oxidation number has increased) from H = 0 to H = +1 ✓

(Reduced):
W (oxidation number has decreased) from W = +6 to W = 0 ✓</td><td>2</td><td>ALLOW 6+ OR 6 OR 1+ OR 1
ALLOW one mark for correct oxidation number changes H = 0 to H = +1 AND W = +6 to W = 0
ALLOW oxidation states written above the equation if not seen in the text BUT IGNORE oxidation states written above the equation if seen in the text
ALLOW for one mark: (Oxidised) H has increased by 1 AND (Reduced) W has decreased by 6

IGNORE WO_3 is reduced
IGNORE references to electron loss / gain if correct

DO NOT ALLOW incorrect references to electron loss / gain
DO NOT ALLOW ‘H oxidised and W reduced’ without reference to oxidation number changes</td></tr>
</table>

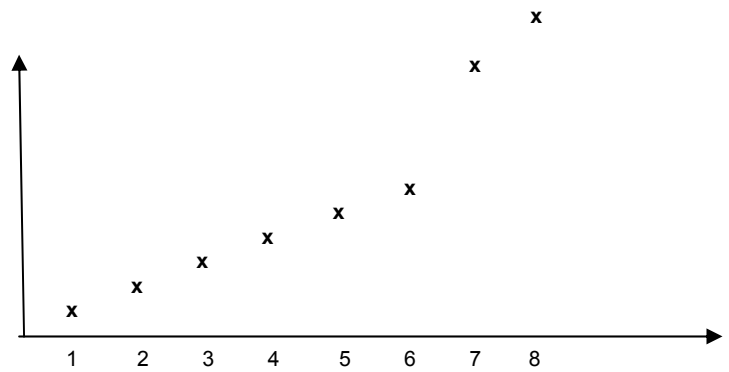
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Question			Answer	Marks	Guidance
1	(b)	(ii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **IF answer = 3.6(0) (dm^3) award 3 marks**	3	**If there is an alternative answer, check to see if there is any ECF credit possible using working below** **ALLOW** calculator value or rounding to 2 significant figures or more BUT **IGNORE** 'trailing' zeroes, eg 0.200 allowed as 0.2 if wrong M_r produces such numbers throughout. **IF** answer **= 1.2(0)** dm^3 award 2 marks (not multiplying by 3)
			Amount of WO_3 = (11.59 / 231.8 =) 0.05(00) (mol) ✓		**ALLOW** use of inexact M_r (eg 232) – if it still gives 0.05
			Amount of H_2 = 0.0500 x 3 = 0.15(0) (mol) ✓		**ALLOW** amount of WO_3 x 3 correctly calculated for 2nd mark
			Volume of H_2 = 0.150 x 24.0 = 3.6(0) (dm^3) ✓		**ALLOW** amount of H_2 x 24.0 correctly calculated for 3rd mark **ALLOW** 1 mark for **incorrect** amount of WO_3 x 24.0 (not multiplied by 3 ie scores third mark only)
			Total	**8**	

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Question			Answer	Marks	Guidance
2	(a)		A shared pair of electrons ✓	1	**DO NOT ALLOW** 'shared electrons'
	(b)	(i)	**Pairs** of (electrons surrounding a central atom) repel ✓ The shape is determined by the number of bond pairs **AND** the number of lone pairs (of electrons) ✓	2	**ALLOW** alternative phrases/words to repel eg 'push apart' **ALLOW** lone pairs repel **OR** bond(ing) pairs repel **ALLOW** 'the number of bonding pairs and number of lone pairs decides the orientation of the surrounding atoms' **ALLOW** 'how many' for 'number of' **ALLOW** the second mark for a response which has 2 of the following **including at least one** shape involving lone pairs (of electrons) BUT mark incorrect responses first 2 bonding pairs = linear 3 bonding pairs = trigonal planar 4 bonding pairs = tetrahedral 6 bonding pairs = hexagonal 3 bonding pairs and 1 lone pair = pyramidal 2 bonding pairs and 2 lone pairs = non-linear **IGNORE** 'number of electron pairs decides shape of molecule' as this is in the question
		(ii)	O–B–O = 120° ✓ B–O–H = 104.5° ✓	2	**ALLOW** 104–105°
	(c)		SF_6 **OR** sulfur hexafluoride **OR** sulfur(VI) fluoride ✓	1	**ALLOW** XeF_4 **DO NOT ALLOW** SCl_6 **DO NOT ALLOW** stated complexes (simple molecule is asked for)
			Total	**6**	

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Question			Answer	Marks	Guidance
3	(a)		Energy (needed) to remove an electron ✓ from **each atom** in **one mole** ✓ of **gaseous atoms** ✓	3	**ALLOW** 'energy to remove one mole of electrons from one mole of gaseous atoms' for three marks **IGNORE** 'element' **ALLOW** 'energy needed to remove an electron from one mole of gaseous atoms to form one mole of gaseous 1+ ions' for two marks For third mark: **ALLOW** ECF if wrong particle is used in second marking point but is described as being gaseous eg 'molecule' instead of 'atom' **IGNORE** equations
	(b)	**(i)**	$O^+(g) \rightarrow O^{2+}(g) + e^-$ ✓	1	**ALLOW** $O^+(g) - e^- \rightarrow O^{2+}(g)$ **ALLOW** e for electron (ie charge omitted) **IGNORE** states on the electron
		(ii)	 All eight ionisation energies showing an increase ✓ The biggest increase between the sixth and seventh ionisation energy **AND** 8th ionisation energy is higher than 7th ✓	2	**IGNORE** the 2p/2s true jump **IGNORE** line if seen **IGNORE** 0, if included by candidate **IGNORE missing** 1st IE point BUT **DO NOT ALLOW** first ionisation energy higher than second **DO NOT ALLOW** either mark if ionisations energies 3 to 8 inclusive are not shown Place tick for second mark on the x-axis between 6 and 7

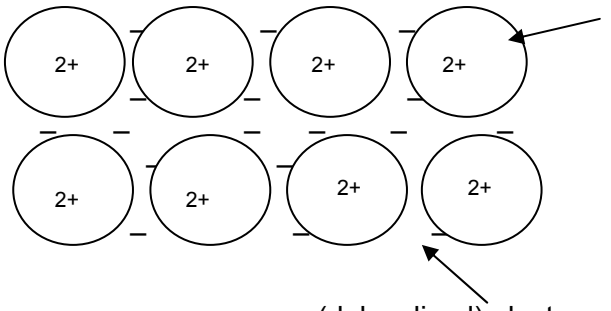
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Question			Answer	Marks	Guidance
3	(c)			3	**Use annotations ie ticks crosses ECF ^ etc for this part** Comparison should be used for each mark. Look for ORA from perspective of F throughout. **ALLOW** all three marks applied to 'as you go across the period' BUT assume the response refers to 'as you go across the period' if not stated
			Nuclear charge mark O has (one) less proton(s) **OR** O has smaller nuclear charge **OR** F has (one) more proton(s) **OR** F has greater nuclear charge ✓		**ALLOW** O has lower proton number BUT **IGNORE** O has lower atomic number **IGNORE** O has a smaller nucleus **IGNORE** 'O has a smaller charge' ie must be nuclear charge **IGNORE** 'O has smaller effective nuclear charge'
			Atomic radius/shielding mark (Outermost) electrons are in the same shell **OR** energy level **OR** (Outermost) electrons experience the same shielding **OR** Atomic radius of O is larger **OR** Atomic radius of F is smaller ✓		**ALLOW** sub-shell for shell but **IGNORE** orbitals **ALLOW** shielding is similar **ALLOW** outermost electrons of O are further **DO NOT ALLOW** 'distance is the same' for second mark
			Nuclear attraction mark Less nuclear attraction (on outermost electrons) in O **OR** (outer) electrons are attracted less strongly (to the nucleus) in O **OR** More nuclear attraction (on outermost electrons) in F **OR** (outer) electrons are attracted more strongly (to the nucleus) in F ✓		**ALLOW** 'less nuclear pull' for 'less nuclear attraction' **DO NOT ALLOW** 'less nuclear charge' instead of 'less nuclear attraction' for the third mark **IGNORE** 'not pulled as close' for 'pulled less strongly'

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Question			Answer	Marks	Guidance
3	(d)		$1s^2\ 2s^2\ 2p^4$ **AND** $1s^2\ 2s^2\ 2p^6$ ✓ (In the reaction) oxygen has formed a **negative ion** (by gaining (two) electrons) ✓	2	**ALLOW** subscripts, capitals **ALLOW** oxidation number of oxygen has decreased **ALLOW** non metals form negative ions **IGNORE** oxygen has gained electrons (this is shown in the electron configurations)
	(e)	(i)	SO_3^{2-} ✓ ClO_2^- ✓	2	
		(ii)	$Al(NO_3)_3$ ✓	1	
		(iii)	Aluminium oxide **OR** aluminium hydroxide ✓ HNO_3 ✓	2	**IGNORE** correct formula (ie Al_2O_3 or $Al(OH)_3$) **DO NOT ALLOW** correct name with incorrect formula **IGNORE** correct name (ie nitric acid or nitric(V) acid) **DO NOT ALLOW** correct formula with incorrect name **ALLOW** one mark for Al_2O_3 or $Al(OH)_3$) **AND** nitric acid or nitric(V) acid (ie name answer and formulae answer has been transposed)
			Total	**16**	

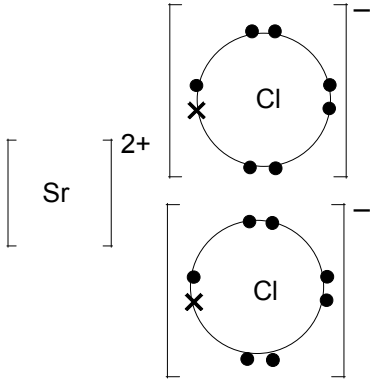
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Question	Answer	Marks	Guidance
4 (a)	 Diagram showing a regular arrangement of **labelled** '**Ba^{2+} ions**' or '**2+ ions**' and some attempt to show electrons ✓ Scattering of labelled electrons between other species **AND** statement anywhere of **delocalised** electrons (can be in text or in diagram) ✓ The attraction between (positive) ions and (delocalised) electrons is strong ✓	3	Regular arrangement must have at least two rows of correctly charged ions and a minimum of two ions per row **ALLOW** as label: positive ions, cations if correct charge is seen within circle **ALLOW** for labelled Ba^{2+} ions: circles with **Ba^{2+}** inside **DO NOT ALLOW** incorrect charge for ions eg + , 3+ etc **DO NOT ALLOW** for label of ions: nuclei **OR** positive atom **OR** protons **ALLOW** e^- or 'e' or – as symbol for electron within the lattice for first marking point if not labelled as 'electrons'. **ALLOW** mobile or 'sea of' for delocalised *Quality of written communication:* 'electron(s)' spelled correctly and used in context for the **third** marking point **ALLOW** a lot of energy is needed to break **OR** overcome the attraction between (positive) ions and (delocalised) electrons **IGNORE** 'heat' but **ALLOW** 'heat energy' **DO NOT ALLOW** references to incorrect particles or incorrect attractions eg 'intermolecular attraction' **OR** 'nuclear attraction' **IGNORE** 'strong metallic bonds' without seeing correct description of metallic bonding

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Question			Answer	Marks	Guidance
4	(b)	(i)	$Ba(s) + 2H_2O(l) \rightarrow Ba(OH)_2(aq) + H_2(g)$ $Ba(OH)_2$ as product ✓ Rest of equation + state symbols ✓	2	**ALLOW** multiples
		(ii)	Any value or the range $7 < pH \leq 14$ ✓	1	**DO NOT ALLOW** if pH 7 is in a quoted range
		(iii)	OH^- **OR** HO^- ✓	1	**DO NOT ALLOW** Ba^{2+} **DO NOT ALLOW** any reference to electrons
	(c)		Magnesium hydroxide **OR** magnesium oxide ✓	1	**ALLOW** magnesium carbonate **ALLOW** correct formulae: $Mg(OH)_2$, MgO, $MgCO_3$ **IGNORE** 'milk of magnesia'
	(d)	(i)	Effervescence **OR** fizzing **OR** bubbling **OR** gas produced **AND** Strontium carbonate **OR** solid dissolves **OR** disappears **OR** a colourless solution is formed ✓ $SrCO_3 + 2HCl \rightarrow SrCl_2 + H_2O + CO_2$ ✓	2	**DO NOT ALLOW** 'carbon dioxide produced' without 'gas' **DO NOT ALLOW** 'hydrogen gas produced' **OR** any other named gas **ALLOW** 'it' for strontium carbonate **ALLOW** strontium for strontium carbonate if $SrCO_3$ seen in equation **IGNORE** 'reacts' **IGNORE** references to temperature change **IGNORE** 'steam produced' **IGNORE** state symbols

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Question			Answer	Marks	Guidance
4	(d)	(ii)	 Strontium ion with eight (or no) outermost electrons **AND** 2 x chloride (ions) with '*dot-and-cross*' outermost octet ✓ correct charges ✓	2	**For first mark**, if eight electrons are shown in the cation then the 'extra' electron in the anion must match symbol chosen for electrons in the cation **IGNORE** inner shell electrons Circles **not** essential **ALLOW** One mark if both electron arrangement and charges are correct but only one Cl is drawn **ALLOW** $2[Cl^-]$ $2[Cl]^-$ $[Cl^-]_2$ (brackets not required) **DO NOT ALLOW** $[Cl_2]^-$ $[Cl_2]^{2-}$ $[2Cl]^{2-}$ $[Cl]_2^-$
	(e)	(i)	The mixture would turn orange ✓	1	**ALLOW** shades and colours containing (eg dark orange, yellow-orange) **ALLOW** the following: yellow, yellow-brown, brown, brown-red BUT **DO NOT ALLOW** red alone **IGNORE** initial colours **DO NOT ALLOW** any response that includes 'precipitate' **OR** solid
		(ii)	$Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$ ✓	1	**ALLOW** multiples **IGNORE** state symbols

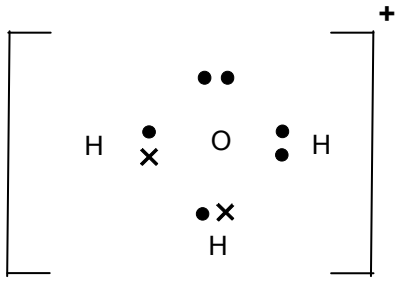
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Question			Answer	Marks	Guidance
4	e	(iii)	*The electron* GAIN *mark* Chlorine will form a negative ion more easily than bromine **OR** Chlorine will gain an electron more easily than bromine ✓ *Atomic size mark* (An atom of) chlorine is smaller (than bromine) ✓ *Shielding mark* (Outermost shell of) chlorine is less shielded (than bromine) ✓ *Stronger nuclear attraction mark* Nuclear attraction (on the electron to be gained) by chlorine is greater (than bromine) **OR** the electron (to be gained) is attracted more strongly (to the nucleus) in chlorine ✓	4	**Use annotations ie ticks crosses ECF ^ etc for this part** Look for ORA from perspective of Br throughout. **ALLOW** all four marks applied to 'as you go up **OR** as you down the group' **ALLOW** C*l* for chlorine **AND** Br for bromine **ALLOW** ORA **DO NOT ALLOW** the use of 'ide' BUT **ALLOW** use of 'ide' as an ECF **ALLOW** chlorine is better at electron capture **ALLOW** chlorine has greater electron affinity **IGNORE** chlorine is more electronegative **IGNORE** chlorine has more oxidising power than bromine **IGNORE** explanations given in terms of displacement **ALLOW** chlorine has fewer shells **ALLOW** the electron is added to the (outer) shell closer to the nucleus **IGNORE** 'easily' for 'greater' or for 'stronger' **ALLOW** 'chlorine has greater nuclear attraction (on its outermost electrons)' **OR** '(the outermost) electrons in chlorine are more attracted (to the nucleus)'
			Total	**18**	

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Question			Answer	Marks	Guidance
5	(a)		*F_2 forces mark* F_2 has van der Waals' (forces) **OR** F_2 has induced dipole attractions **OR** interactions **OR** F_2 has temporary **OR** instantaneous dipole(–dipole) attraction **OR** interactions ✓ *HCl forces mark* HCl has **permanent** dipole(–dipole) attractions **OR** interactions ✓ *Comparison of strength of forces between molecules mark* intermolecular force in HCl is stronger than that in F_2 **OR** permanent dipoles are stronger (than induced dipoles) ✓ *Boiling point mark* more energy is required to break stronger (intermolecular) forces ✓	4	**Use annotations ie ticks crosses ECF ^ etc for this part** **ALLOW** vdWs for van der Waals' **IGNORE** F_2 has covalent bond for this mark **IGNORE** F_2 has 'intermolecular forces' *Quality of written communication:* 'dipole(s)' spelled correctly and used in context for the **second** marking point **IGNORE** HCl has 'intermolecular forces' **IGNORE** van der Waals' forces in HCl **DO NOT ALLOW** hydrogen bonding **DO NOT ALLOW** ionic bonding Look for strength of force comparison anywhere in the answer **ALLOW** ECF for hydrogen bonding in HCl being stronger than the stated intermolecular forces in F_2 BUT **DO NOT ALLOW** this mark if HCl or F_2 has covalent bonds broken **OR** if HCl has ionic bonds broken (the question asks for forces between molecules) **IGNORE** HCl has stronger van der Waals' (forces) than F_2 (as they both have the same number of electrons) **DO NOT ALLOW** fourth mark if covalent bonds are broken in HCl or F_2 **OR** if ionic bonds are broken in HCl **IGNORE** 'heat' but **ALLOW** 'heat energy'

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Question			Answer	Marks	Guidance
5	(b)	(i)	 Two *dot-and-cross* bonding pairs of electrons and one dative covalent bond pair of electrons consisting of either two dots or two crosses ✓ **One** non-bonding pair of electrons **AND** which match the dative covalent bond pair of electrons ✓	2	Must be '*dot-and-cross*' Must be H_3O for either mark Circles for shells **not** needed **IGNORE** inner shells **IGNORE** lack of positive charge and square brackets **DO NOT ALLOW** second marking point if negative charge is shown on the ion Non-bonding electrons do **not** have to be seen as a pair **ALLOW** second mark for one non-bonding pair of electrons and three *dot-and-cross* bonding pairs of electrons

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Question			Answer	Marks	Guidance
5	(c)	(i)	FIRST CHECK THE ANSWER ON ANSWER LINE IF answer = 7.624 OR 7.62 (g) award 3 marks Molar mass of borax = 381.2 (g mol^{-1}) ✓ Correctly calculates the mass of borax in 1000 cm^3 = 0.0800 x 381.2 = 30.496 g **OR** 30.50 g **OR** 30.5g ✓ Correctly calculates the mass of borax in 250 cm^3 = 30.496/4 = 7.624 g **OR** 7.62 g ✓ **OR** Molar mass of borax = 381.2 (g mol^{-1}) ✓ Amount of borax in 250 cm^3 of solution = 0.0800 x 250 /1000 = 0.02(00) mol ✓ Mass of borax = 0.02(00) x 381.2 of borax = 7.624 g **OR** 7.62 g ✓	3	If there is an alternative answer, check to see if there is any ECF credit possible using working below **ALLOW** 381 **DO NOT ALLOW** 380 **ALLOW** 0.0800 x [molar mass of borax] correctly calculated for 2nd mark (ie mass of borax in 1000 cm^3) **ALLOW** [mass of borax in 1000 cm^3] / 4 correctly calculated for 3rd mark **ALLOW** calculator value or rounding to **three** significant figures or more **IGNORE** (if seen) a second rounding error **ALLOW** 381 **DO NOT ALLOW** 380 **ALLOW** [incorrect amount of borax] x 381.2 **OR** [incorrect amount of borax] x [incorrect molar mass of borax] **OR** 0.02(00) x [incorrect molar mass of borax] correctly calculated for this mark **ALLOW** calculator value or rounding to **three** significant figures or more **IGNORE** (if seen) a second rounding error

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Question			Answer	Marks	Guidance
5	(d)	(i)	Correctly calculates the amount of borax used = 0.0800 x 22.5/1000 = 1.8(0) x 10^{-3} mol **OR** 0.0018(0) mol ✓	1	
		(ii)	Correctly calculates the amount of HC*l* used = 1.8(0) x 10^{-3} x 2 mol = 3.6(0) x 10^{-3} mol **OR** 0.0036(0) mol ✓	1	**ALLOW** [incorrect amount of borax] x 2 correctly calculated for the 2nd mark. **ALLOW** calculator value or rounding to 3 significant figures or more **BUT IGNORE** 'trailing' zeroes, eg 0.200 allowed as 0.2
		(iii)	Correctly calculates the concentration of HC*l* = 3.6(0) x 10^{-3} / (25 / 1000) = 0.144 (mol dm^{-3}) ✓	1	**ALLOW** [incorrect amount of HC*l*] / (25/1000) correctly calculated for the 3rd mark given to 3 SF
			Total	**12**	

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RECOGNISING ACHIEVEMENT

Tuesday 15 May 2012 – Afternoon

AS GCE CHEMISTRY A

F321 Atoms, Bonds and Groups

Candidates answer on the Question Paper.

OCR supplied materials:
- *Data Sheet for Chemistry A* (inserted)

Other materials required:
- Scientific calculator

Duration: 1 hour

F 3 1 4 6 0 0 6 1 2

F 3 2 1

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The Insert will be found in the centre of this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
-  Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry A* 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**.
- This document consists of **12** pages. Any blank pages are indicated.

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Answer **all** the questions.

1 Sulfur, atomic number 16, is found within the Earth's crust. Sulfur is released into the atmosphere at times of volcanic activity.

A sample of sulfur from a volcano was analysed to give the following composition of isotopes.

isotope	abundance (%)
^{32}S	95.02
^{33}S	0.76
^{34}S	4.22

(a) Define the term *relative atomic mass*.

.....

.....

.....

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

(b) Calculate the relative atomic mass of the sample of sulfur.

Give your answer to **two** decimal places.

answer = ... **[2]**

(c) John Dalton, an early 19th century scientist, believed that elements were made up of tiny particles called atoms which could not be divided. Nowadays, chemists know of the existence of sub-atomic particles in atoms and in ions.

Complete the table to show the number of sub-atomic particles in the ^{33}S atom and $^{34}S^{2-}$ ion.

	protons	neutrons	electrons
^{33}S			
$^{34}S^{2-}$			

[2]

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(d) Solid sulfur exists as a lattice of S_8 molecules. Each S_8 molecule is a ring of eight atoms.

How many atoms of sulfur are there in 0.0120 mol of S_8 molecules?

answer = ... atoms **[2]**

(e) The only intermolecular forces in solid sulfur are van der Waals'.

(i) Describe how van der Waals' forces arise.

.....

.....

.....

.....

.....

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

(ii) Suggest why there are **no** other intermolecular forces in solid sulfur.

.....

.....

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

(f) Sodium thiosulfate is a compound of sulfur used to develop photographs.

Hydrated sodium thiosulfate has the formula $Na_2S_2O_3 \bullet 5H_2O$.

What is the oxidation number of sulfur in $Na_2S_2O_3 \bullet 5H_2O$?

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

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(g) A student heats 12.41 g of hydrated sodium thiosulfate, $Na_2S_2O_3 \bullet 5H_2O$, to remove the water of crystallisation. A white powder called anhydrous sodium thiosulfate forms.

(i) What does the term *anhydrous* mean?

.....

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

(ii) What is the relative formula mass of $Na_2S_2O_3 \bullet 5H_2O$?

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

(iii) Calculate the expected mass of anhydrous sodium thiosulfate that forms.

mass = ... g **[2]**

(h) Sulfur hexafluoride, SF_6, exists as non-polar covalent molecules with an octahedral shape.

(i) Explain why a molecule of SF_6 has an octahedral shape.

.....

.....

.....

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

(ii) Fluorine has a higher electronegativity than sulfur, yet SF_6 molecules are non-polar.

Explain what is meant by the term *electronegativity* and suggest why SF_6 molecules are non-polar.

.....

.....

.....

.....

.....

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

[Total: 23]

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TURN OVER FOR QUESTION 2

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2 Chemists can use the Periodic Table to predict the behaviour of elements.

(a) What is the name of the term used to describe the repeating patterns in the Periodic Table?

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

(b) Melting points show a trend across a period.

The table below shows the melting points of three elements in Period 3 of the Periodic Table.

element	aluminium	silicon	phosphorus
melting point / °C	660	1410	44

Explain the trend shown in terms of bonding and structure.

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

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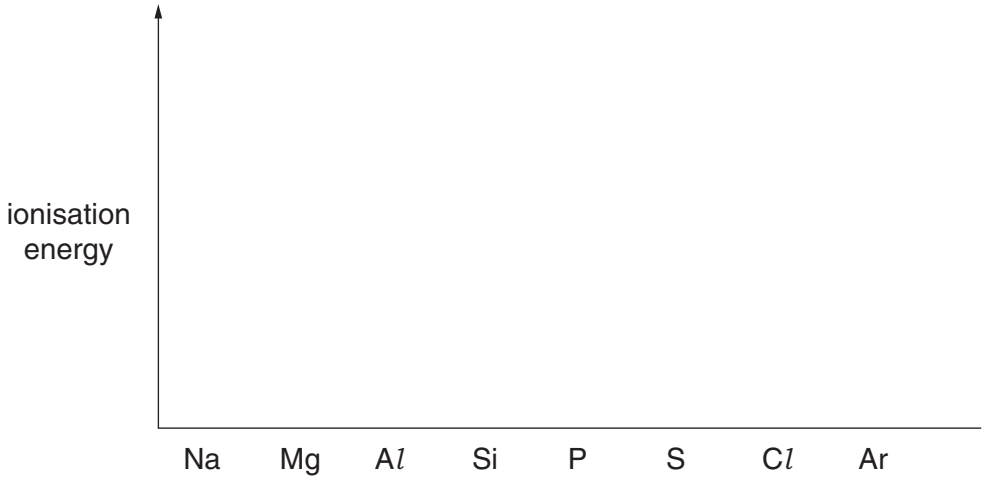
..... **[6]**

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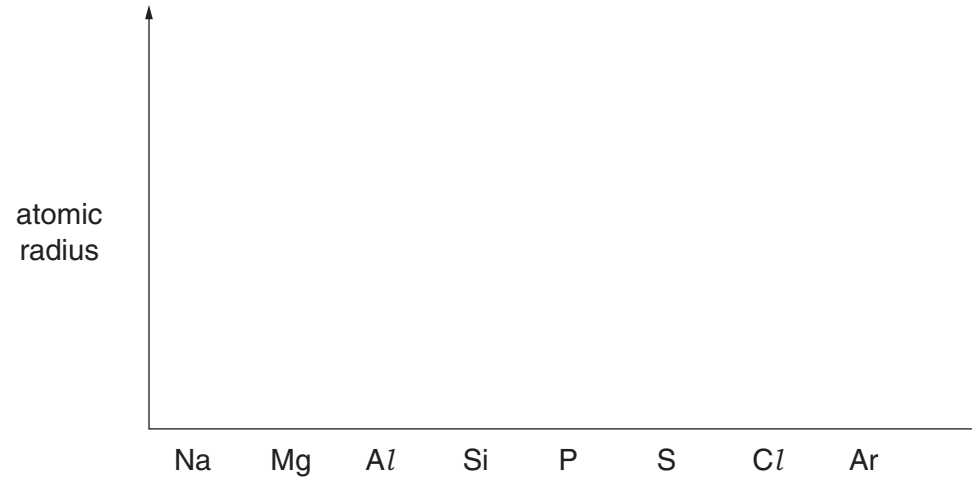
(c) Scientists use 'sketch graphs' to show trends.

(i) Draw a sketch graph to show the general trend in **ionisation energy** across Period 3.



[1]

(ii) Draw a sketch graph to show the general trend in **atomic radius** across Period 3.



[1]

[Total: 9]

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3 Magnesium and strontium are typical Group 2 metals.

(a) Complete the electron configuration of a magnesium atom.

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

(b) The second ionisation energy of magnesium is 1064 kJ mol^{-1}.

(i) Write an equation to represent the second ionisation energy of magnesium. Include state symbols.

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

(ii) Magnesium has a greater second ionisation energy than strontium.

Explain why.



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

.....

.....

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.....

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.....

.....

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

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(c) A student watches a demonstration in which strontium is added to water.

The equation for the reaction is shown below.

$$Sr(s) + 2H_2O(l) \rightarrow Sr(OH)_2(aq) + H_2(g)$$

(i) Write the formulae of the aqueous ions formed when this reaction takes place.

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

(ii) In terms of electron transfer, explain why strontium has been oxidised.

.....

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

(iii) Suggest two **compounds** which could be reacted together to produce $Sr(OH)_2$.

.....

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

(d) $Sr(OH)_2$ can react with an acid to form $SrSO_3$.

(i) The systematic name for $SrSO_3$ is strontium sulfate(IV).

Why does the number (IV) have to be used here rather than simply naming this compound as strontium sulfate?

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

(ii) Suggest the formula of the acid used to form $SrSO_3$.

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

[Total: 12]

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4 Chlorine and its compounds have wide uses in chemistry.

(a) In drinking water, HC*l*O kills bacteria.

(i) Write an equation to show how HC*l*O can form in drinking water.

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

(ii) Some scientists believe that chlorine compounds should **not** be present in drinking water.

Suggest **one** reason why scientists may be worried by the presence of these compounds.

.....

.....

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

(b) Chlorine reacts directly with Group 2 elements to form chlorides that are very soluble in water.

Aqueous chloride ions can be detected by adding aqueous silver nitrate.
The appearance of solid silver chloride, AgC*l*, confirms the presence of chloride ions.

(i) State the type of reaction that has taken place.

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

(ii) Write the ionic equation for this reaction.
Include state symbols.

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

(c) A student is given a sample of an unknown Group 2 chloride.

- The student dissolves 2.86 g of the chloride in water.
- The student adds excess aqueous silver nitrate.
- 8.604 g of solid silver chloride, AgC*l*, forms.

(i) Calculate the amount, in moles, of AgC*l* that forms.

The molar mass of AgC*l* = 143.4 g mol^{-1}.

answer = ... mol **[1]**

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(ii) Deduce the amount, in moles, of the Group 2 chloride that the student dissolves.

Hence deduce the relative atomic mass and the identity of the Group 2 metal.
Give the relative atomic mass to **one** decimal place.

You **must** show your working.

relative atomic mass = ...

Group 2 metal = ... **[3]**

(d) Ammonium chloride, NH_4Cl, is a salt which has covalent bonding, dative covalent (coordinate) bonding and ionic bonding.

(i) What is a *dative covalent* (*coordinate*) bond?

.....

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

(ii) Give the formulae of the ions present in NH_4Cl.

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

(iii) Draw a '*dot-and-cross*' diagram to show the bonding in NH_4Cl.
Show the outer electrons only.

[2]

TURN OVER FOR QUESTION 4(e)

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(e) A teacher heats potassium chlorate(V), $KClO_3$. The equation is given below.

$$2KClO_3(s) \longrightarrow 2KCl(s) + 3O_2(g)$$

(i) This is an example of a redox reaction.

What other type of reaction takes place?

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

(ii) The teacher heats 0.824 g of $KClO_3$.

Calculate the volume of oxygen produced, in cm^3, measured at room temperature and pressure.

Give your answer to the **nearest whole number**.

answer = ... cm^3 **[3]**

[Total: 16]

END OF QUESTION PAPER

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RECOGNISING ACHIEVEMENT

GCE

Chemistry A

Advanced Subsidiary GCE

Unit **F321:** Atoms, Bonds and Groups

Mark Scheme for June 2012

Oxford Cambridge and RSA Examinations

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All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

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Annotations

Annotation	Meaning
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Ignore
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error
	Error in number of significant figures
	Correct response

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Subject-specific Marking Instructions

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

The following questions should be annotated with ticks to show where marks have been awarded in the body of the text: **1(e)(i), 2(b), 3(b)(ii)**

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Question			Answer	Marks	Guidance
1	(a)		The (weighted) mean **mass** of an **atom** (of an element) **OR** The (weighted) average **mass** of an **atom** (of an element) ✓ compared with 1/12th (the mass) ✓ of (one atom of) carbon-12 ✓	3	**ALLOW** average atomic mass **DO NOT ALLOW** mean mass of an element **ALLOW** mean mass of isotope**s** **OR** average mass of isotope**s** **DO NOT ALLOW** the singular; 'isotope' For second **and** third marking points **ALLOW** compared with (the mass of) carbon-12 which is 12 **ALLOW** mass of **one mole** of **atoms** ✓ compared to 1/12th ✓ (mass of) **one mole OR** 12**g** of carbon-12 ✓ **ALLOW** mass of **one mole** of atoms / 1/12th mass of **one mole** OR 12**g** of carbon-12
	(b)		**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 32.09 award 2 marks** $\frac{32 \times 95.02 + 33 \times 0.76 + 34 \times 4.22}{100}$ **OR** 30.4064 + 0.2508 + 1.4348 **OR** = 32.092 (calculator value) ✓ (A_r =) 32.09 ✓	2	**ALLOW** one mark for ECF from transcription error in first sum provided final answer is to 2 decimal places and is between 32 and 34 and is a correct calculation of the transcription Answer must be 2 decimal places

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<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>1</td><td>(c)</td><td></td><td>
<table>
<tr><th></th><th>protons</th><th>neutrons</th><th>electrons</th></tr>
<tr><td>^{33}S</td><td>16</td><td>17</td><td>16</td></tr>
<tr><td>$^{34}S^{2-}$</td><td>16</td><td>18</td><td>18</td></tr>
</table>
✓
✓
</td><td>2</td><td>Mark by row</td></tr>
<tr><td></td><td>(d)</td><td></td><td>FIRST CHECK THE ANSWER ON THE ANSWER LINE
If answer = 5.78 × 10^{22} award 2 marks

(mol of atoms) = 0.0120 × 8 = 0.0960 (mol)
OR
(no. of molecules) = 0.0120 × 6.02 × 10^{23} = 7.224 x 10^{21}
OR
(no. of S atoms in 1 mole of S_8) = 8 x 6.02 x 10^{23} = 4.816 x 10^{24}✓

Correctly calculates (number of atoms) = 0.0120 × 8 × 6.02 × 10^{23}

= 5.78 × 10^{22} (atoms) ✓</td><td>2</td><td>If there is an alternative answer, check to see if there is any ECF credit possible using working below

ALLOW 5.8 x 10^{22} up to calculator value of 5.7792 x 10^{22}
ALLOW correct rounding of ECF to 2 significant figures or more up to calculator value
ALLOW answers in non standard form such as 0.578 × 10^{23} correctly rounded to 2 or more significant figures</td></tr>
<tr><td></td><td>(e)</td><td>(i)</td><td>Creating the dipole mark
Uneven distribution of electrons ✓

Type of dipole mark
Creates or causes an instantaneous dipole OR temporary dipole (in a molecule) ✓

Induction of a second dipole mark
Causes induced dipoles in neighbouring molecules ✓</td><td>3</td><td>Use annotations with ticks, crosses, ECF etc for this part
ALLOW movement of electrons
ALLOW changing electron density

ALLOW ‘transient’, ‘oscillating’ ‘momentary’ ‘changing’
DO NOT ALLOW induces a temporary dipole for the second marking point

ALLOW induces a dipole in neighbouring molecules
ALLOW causes a resultant dipole in other molecules
ALLOW atoms for molecules</td></tr>
</table>

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Question			Answer	Marks	Guidance
1	(e)	(ii)	Only one type of atom **OR** No (permanent) dipoles **OR** non-polar **OR** no polar bonds ✓	1	**ALLOW** no difference in electronegativity **IGNORE** 'No hydrogen bonding' **IGNORE** 'No lone pairs'
	(f)		+ 2 ✓	1	**ALLOW** 2(+)
	(g)	(i)	There are no waters of crystallisation ✓	1	**ALLOW** 'without water' 'no water' etc **IGNORE** dehydrated
		(ii)	248.2 ✓	1	**IGNORE** units **DO NOT ALLOW** 248
		(iii)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 7.91 (g) award 2 marks** (amount of $Na_2S_2O_3 \cdot 5H_2O$) = 12.41/248.2 **OR** = 0.05(00) (mol) ✓ (mass of $Na_2S_2O_3$) = 0.05 x 158.2 = 7.91 (g) ✓	2	If there is an alternative answer, check to see if there is any ECF credit possible using working below **ALLOW** ECFs from answer to **(g)(ii)** for both marking points **ALLOW** ECF for calculated mol of $Na_2S_2O_3 \cdot 5H_2O$ x 158.2 correctly calculated for the 2nd mark **ALLOW** calculator value or rounding to 3 significant figures or more but **IGNORE** 'trailing' zeroes, eg 0.200 allowed as 0.2

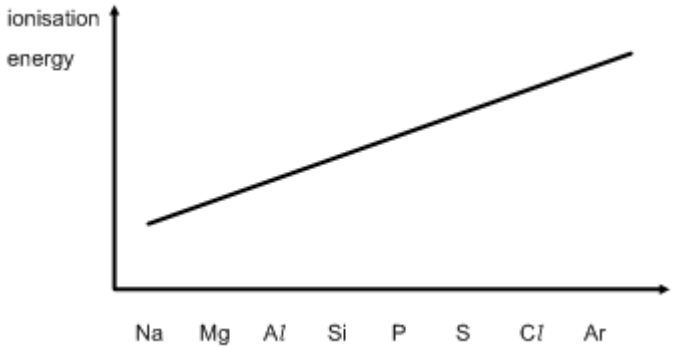
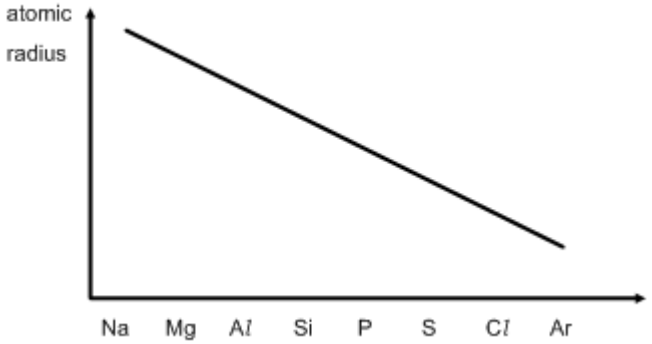
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Question			Answer	Marks	Guidance
1	(h)	(i)	Sulfur has six bonded pairs (and no lone pairs) ✓ Electron pairs repel (one another equally) ✓	2	**ALLOW** 'It has six bonded pairs' **ALLOW** bonds for bonded pairs **IGNORE** regions **OR** areas of negative charge **ALLOW** 'bonds repel' **DO NOT ALLOW** 'Atoms repel' or 'electrons repel' 'Lone pairs repel more than bonded pairs' would score the second mark but would contradict the first mark if there is no reference to no lone pairs
		(ii)	The ability of an atom to attract electrons ✓ in a (covalent) bond ✓ (The octahedral shape) is symmetrical ✓	3	 **ALLOW** dipoles cancel out **IGNORE** polar bonds repel **IGNOR**E charges cancel
			Total	**23**	

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Question			Answer	Marks	Guidance
2	(a)		Periodicity ✓	1	**ALLOW** phonetic versions
	(b)		***Al bonding mark*** Al has metallic (bonding) **OR** has (electrostatic) attraction between positive ions and (delocalised) electrons ✓ ***Si bonding mark*** Si has covalent (bonding) **OR** has shared pairs of electrons between atoms ✓ ***P bonding mark*** P has **induced** dipoles **OR** has van der Waals' forces (between molecules) ✓ ***Structure mark 1*** Al **AND** Si are Giant ✓ ***Structure mark 2*** P is Simple molecular **OR** simple covalent ✓ ***Bond strength mark*** Metallic **AND** covalent are stronger than vdWs **OR** Bonds broken in Al **AND** in Si are stronger than the forces broken in P **OR** More energy is needed to overcome bonds in Al **AND** Si than the forces in P ✓	6	**Use annotations with ticks, crosses, ECF etc for this part** **DO NOT ALLOW** marking point 1 if Al has dipoles **OR** intermolecular forces **OR** molecules **OR** atoms **OR** attraction between nuclei and electrons **OR** attraction between oppositely charged ions **DO NOT ALLOW** marking point 2 if Si has dipoles **OR** intermolecular forces **OR** molecule**s** but **IGNORE** 'molecule' Must be induced dipoles **ALLOW** vdW for van der Waals' **IGNORE** P has covalent bonds for marking point 3 **Quality of Written Communication: 'giant' spelled correctly once and used in context for the fourth marking point** **DO NOT ALLOW** covalent bonds are broken in phosphorus for marking point 6, but **ALLOW** answers that inform Al and Si are stronger than P, ignoring incorrect forces or bonds used above **IGNORE** 'heat' but **ALLOW** 'heat energy'

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Question			Answer	Marks	Guidance
2	(c)	(i)	Increasing straight line **OR** curve from Na to Ar ✓  	1	**ALLOW** bar charts **OR** points **IGNORE** the standard of drawing as long as the trend is clear **IGNORE** decrease between Mg/Al and P/S Essentially the mark is for Na < Mg < Si < P < Cl < Ar **AND** Al < Si **AND** S< Cl
		(ii)	Decreasing straight line **OR** curve from Na to Ar ✓  	1	**ALLOW** bar charts **OR** points **IGNORE** the standard of drawing as long as the trend is clear **IGNORE** Ar Essentially the mark is for Na > Mg > Al > Si > P > S > Cl
			Total	**9**	

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Question			Answer	Marks	Guidance
3	(a)		$(1s^2)\ 2s^2\ 2p^6\ 3s^2$ ✓	1	**IGNORE** $1s^2$ seen twice **ALLOW** subscripts
	(b)	(i)	$Mg^+(g) \rightarrow Mg^{2+}(g) + e^-$ Equation correct ✓ State symbols correct ✓	2	**ALLOW** $Mg^+(g) - e^- \rightarrow Mg^{2+}(g)$ for 2 marks The second mark is dependent upon the first mark except for the following close attempts for the first mark: **ALLOW** the following for one mark as states are correct $Mg(g) \rightarrow Mg^{2+}(g) + 2e^-$ $Mg(g) + e^- \rightarrow Mg^{2+}(g) + 2e^-$ **ALLOW** e for electron **IGNORE** states on electron
		(ii)	***Ionic radius mark*** $Mg^{(+)}$ has smaller (ionic**)** radius **OR** has less shells ✓ ***Shielding mark*** (outermost electron) of $Mg^{(+)}$ experience less shielding ✓ ***Nuclear attraction mark*** More nuclear attraction on (outermost electrons) **OR** Outer electrons are attracted more strongly (to the nucleus) ✓ **ORA** throughout	3	**Use annotations with ticks, crosses, ECF etc for this part** **ALLOW** $Mg^{(+)}$ has less energy levels **ALLOW** $Mg^{(+)}$ has electrons in lower energy level **ALLOW** $Mg^{(+)}$ has electrons closer to nucleus **IGNORE** $Mg^{(+)}$ has less orbitals **OR** less sub-shells **IGNORE** atomic for ionic **IGNORE** 'different shell' **ALLOW** screening for shielding **ALLOW** $Mg^{(+)}$ has **less** electron repulsion from inner shells **Quality of Written Communication: 'nuclear' OR 'nucleus' OR 'electron(s)' spelled correctly once and used in context for the third marking point** **ALLOW** $Mg^{(+)}$ has more nuclear pull **IGNORE** $Mg^{(+)}$ has more effective nuclear charge **DO NOT ALLOW** more nuclear charge for more nuclear attraction for the third mark

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Question			Answer	Marks	Guidance
3	(c)	(i)	Sr^{2+} ✓ OH^- ✓	2	**ALLOW** $2OH^-$ **ALLOW** 2 marks for $Sr(OH)_2 \rightarrow Sr^{2+} + 2OH^-$ **ALLOW** 1 mark for $Sr^{2+} + 2OH^- \rightarrow Sr(OH)_2$ **IGNORE** H^+
		(ii)	Sr has lost (two) electron**s** ✓	1	**ALLOW** $Sr \rightarrow Sr^{2+} + 2e^-$ **IGNORE** references to oxidation numbers
		(iii)	SrO **AND** H_2O ✓	1	**ALLOW** acceptable alternatives from Sr salts and alkalis eg $SrCl_2$ + NaOH
	(d)	(i)	It shows the oxidation number of the sulfur **OR** the name without the IV is ambiguous ✓	1	**DO NOT ALLOW** 'the **charge** on sulfur' **DO NOT ALLOW** 'shows the oxidation number of the sulfate' **ALLOW** Otherwise it could be $SrSO_4$ **ALLOW** Sulfur has different oxidation numbers AW
		(ii)	H_2SO_3 ✓	1	
			Total	**12**	

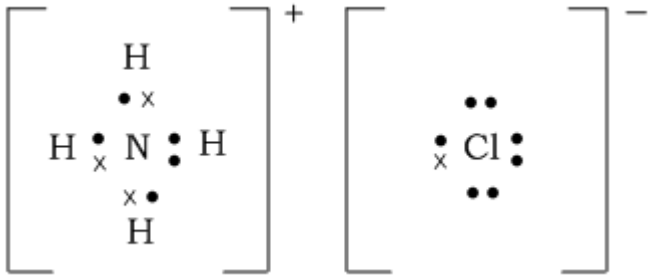
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Question			Answer	Marks	Guidance
4	(a)	(i)	$Cl_2 + H_2O \rightarrow HClO + HCl$ ✓	1	
		(ii)	(Chlorine compounds are) carcinogenic **OR** (Chlorine compounds are) toxic **OR** poisonous ✓	1	**ALLOW** 'they' **OR** 'chlorinated hydrocarbons' **OR** 'it' for 'chlorine compounds' **IGNORE** harmful **OR** dangerous **IGNORE** references to HCl or HClO **IGNORE** chlorine is toxic **DO NOT ALLOW** chlorine is carcinogenic
	(b)	(i)	Precipitation ✓	1	
		(ii)	$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ ✓	1	Equation **AND** state symbols required for mark **DO NOT ALLOW** spectator ions
	(c)	(i)	8.604/143.4 = 0.06(00) (mol) ✓	1	

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Question			Answer	Marks	Guidance
4	(c)	(ii)	If a Group 2 chloride is used amount of Group 2 chloride = ½ × 0.0600 **OR** = 0.0300 mol ✓	3	**DO NOT ALLOW** 24.3 and Mg without appropriate working Check to see if there is any ECF credit possible using working below **ALLOW** calculator value or rounding to 2 significant figures or more but **IGNORE** 'trailing' zeroes, eg 0.200 allowed as 0.2 **ALLOW** ECF for correctly calculated ½ × answer to **(c)(i)**
			Mass of 1 mol of Group 2 chloride = $\frac{2.86}{0.0300}$ = 95.3(3) ✓		Must be at least 1 decimal place for second marking point **ALLOW** ECF for 2.86/mol of metal chloride seen above eg MCl will give 0.0600 mol of metal chloride and this will likely give 2.86/0.0600 = 47.7 *eg MCl_3 will give 0.0200 mol of metal chloride and this will likely give 2.86/0.0200 = 143.0*
			[Relative atomic mass of M = 95.3(3) – 71.0) = 24.3 (g mol^{-1})] **AND** metal = Mg ✓		**ALLOW** ECF for mass of Group 2 chloride – 71.0 provided it is not a negative value **ALLOW** ECF even if molar mass of chloride was given as a whole number above **ALLOW** ECF for mass of metal chloride – 35.5 if amount of metal chloride = 0.0600 mol eg 47.7 – 35.5 = 12.2 **AND** Be ***ALLOW** ECF for mass of metal chloride – 106.5 if amount of metal chloride = 0.0200 mol* *eg 143.0 – 106.5 = 36.5 **AND** Ca*

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Question			Answer	Marks	Guidance
4	(d)	(i)	A shared pair of electrons **AND** both electrons are donated by one atom ✓	1	
		(ii)	NH_4^+ **AND** Cl^- ✓	1	**ALLOW** $NH_4Cl \rightarrow NH_4^+ + Cl^-$ **OR** $NH_4^+ + Cl^- \rightarrow NH_4Cl$
		(iii)	Ammonium ion with three covalent '*dot-and-cross*' bonds **AND** one dative covalent bond ✓ Chloride ion with $8e^-$ **AND** 1 of these electrons different ✓ 	2	**ALLOW** other symbols for dots and crosses eg triangles **IGNORE** charges **IGNORE** 'dative' arrow within the lone pair of the N atom
	(e)	(i)	(Thermal) decomposition ✓	1	

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Question			Answer	Marks	Guidance
4	(e)	(ii)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 242 (cm^3) award 3 marks**	3	**IGNORE** over rounding to two significant figures **once** **DO NOT ALLOW** over rounding to two significant figures twice eg **ALLOW** the following answer for 3 marks **241** (cm^3) (0.00672 was rounded to 0.0067 **OR** 0.0101 was rounded to 0.010) **ALLOW** the following answers for 2 marks **240** (cm^3) (0.00672 was rounded to 0.0067 **AND** 0.0101 was rounded to 0.010) **252** (cm^3) (0.00672 was rounded to 0.007) **161** cm^3 (no multiplying by 3/2)
			(amount of $KClO_3$) = 0.824/122.6 **OR** = 0.00672 (mol) ✓		If there is an alternative answer, check to see if there is any ECF credit possible using working below **ALLOW** up to correctly rounded calculator value of 0.006721044046
			(amount O_2) = (mol of $KClO_3$) 0.00672 × 3/2 **OR** = 0.0101 (mol)		**ALLOW** up to correctly rounded calculator value **ALLOW** ECF for mol of $KClO_3$ × 3/2 for 2nd mark
			(volume of O_2) = 0.0101 × 24 000 = 242 (cm^3) ✓		**ALLOW** ECF for (mol of $KClO_3$) × 3/2 × 24000
			Total	**16**	

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Friday 13 January 2012 – Afternoon

AS GCE CHEMISTRY A

F321 Atoms, Bonds and Groups

Candidates answer on the Question Paper.

OCR supplied materials:
- *Data Sheet for Chemistry A* (inserted)

Other materials required:
- Scientific calculator

Duration: 1 hour

F 3 2 1

F3144201112

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The Insert will be found in the centre of this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry A* 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**.
- This document consists of **12** pages. Any blank pages are indicated.

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Answer **all** the questions.

1 This question is about iodine and its compounds.

(a) Iodine has a stable isotope with a relative isotopic mass of 127.

In 1986, a radioactive isotope of iodine, with a relative isotopic mass of 131, was released into the atmosphere following an explosion at a nuclear power plant in Chernobyl.

(i) Define the term *relative isotopic mass*.

.....

.....

.....

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

(ii) Complete the table to show the number of sub-atomic particles in an atom of iodine-127 and in an atom of iodine-131.

	protons	**neutrons**	**electrons**
iodine-127			53
iodine-131			53

[1]

(b) In the human body, iodide ions, I^-, are necessary for the thyroid gland to function correctly. Some countries add potassium iodide, KI, to table salt as a source of iodide ions.

The Guideline Daily Amount, GDA, of iodide ions is 70.0 µg (1 µg = 1×10^{-6} g).

(i) Calculate the mass of KI, in µg, that would be needed to supply the GDA of iodide ions.

Give your answer to **three** significant figures.

answer = ... µg **[2]**

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(ii) Apart from reasons of cost, suggest why some countries do **not** add KI to table salt.

.....

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

(c) When chlorine gas is bubbled through aqueous potassium iodide, a reaction takes place.

(i) Write the ionic equation for this reaction.

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

(ii) At room temperature, chlorine is a gas and iodine is a solid. When heated together, chlorine reacts with iodine to form iodine monochloride, IC*l*.

IC*l* has a higher boiling point than Cl_2.

Explain, in terms of the intermolecular forces present, why IC*l* has a higher boiling point than Cl_2.



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

.....

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.....

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.....

.....

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

[Total: 9]

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2 Calcium chloride, $CaCl_2$, can be made by different reactions.

A student prepared hydrated calcium chloride by carrying out the following experiment.

Step 1 The student added an excess of a solid calcium compound, **X**, to dilute hydrochloric acid. The mixture fizzed as the solid reacted.

Step 2 The student filtered the mixture to give an aqueous solution of $CaCl_2$.

Step 3 On evaporation, colourless crystals of hydrated calcium chloride were formed.

(a) Describe a chemical test which the student could have carried out to prove that the filtrate contains aqueous chloride ions.

.....

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

(b) A friend of the student suggested that solid **X** was calcium oxide.

State **one** reason why the student's friend was **incorrect** and suggest a possible identity of solid **X**.

reason: .....

.....

solid **X**: ..... **[2]**

(c) Hydrated calcium chloride has a molar mass of 219.1 g mol^{-1}.

(i) What is meant by the term *hydrated* calcium chloride?

.....

.....

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

(ii) Determine the formula of the **hydrated** calcium chloride.

You **must** show your working.

formula = ... **[2]**

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(d) Calcium chloride can also be formed by directly reacting calcium with chlorine gas.

Draw a '*dot-and-cross*' diagram to show the bonding in calcium chloride.

Show outer electrons only.

[2]

(e) The student decided to prepare barium bromide, $BaBr_2$, by directly reacting barium with bromine gas.

The student was unsure whether this preparation would be more reactive or less reactive than the preparation of $CaCl_2$ in **(d)**.

Explain why the student was unsure of the relative reactivity of the two preparations.

.....

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

[Total: 11]

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3 The modern Periodic Table is arranged into blocks of elements based on their electron configuration.

(a) We now know that electrons are in shells; shells have sub-shells and sub-shells have orbitals.

(i) Explain what is meant by the term *orbital*.

.....

.....

.....

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

(ii) Complete the electron configuration below, in terms of sub-shells, for an atom of sulfur.

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

(iii) How many full orbitals are in an atom of sulfur?

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

(b) One mole of sulfur atoms has a mass of 32.1 g.

What is meant by *one mole of substance*?

.....

.....

.....

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

(c) Ionisation energies provide evidence for the order of elements in the modern Periodic Table.

Define the term *first ionisation energy*.

.....

.....

.....

.....

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

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(d) The first ionisation energies and atomic radii of F, Ne and Na are shown below.

element	first ionisation energy / kJ mol^{-1}	atomic radius / nm
F	1681	0.071
Ne	2081	0.065
Na	496	0.191

(i) Explain why there is an increase in first ionisation energy between F and Ne.

.....

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

(ii) Explain why there is a decrease in first ionisation energy between Ne and Na.

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

[Total: 13]

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4 Solid potassium, K, solid potassium bromide, KBr, and ice, H_2O, all exist as lattices.

Their melting points are shown in the table below.

(a) Complete the table.

solid	melting point / °C	type of lattice
K	63	giant metallic
KBr	734	
H_2O	0	

[2]

(b) Explain why there is a difference in the melting points of K, KBr and H_2O.

In your answer you should refer to the types of particle, the types of forces between the particles and the relative strength of the forces between the particles in solid K, KBr and H_2O.

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

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

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(c) Potassium metal reacts with water.

$$2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$$

0.2346 g of potassium is reacted with excess water.

Calculate the volume of gas formed.

The gas volume is measured in cm^3 at room temperature and pressure.

answer = ... cm^3 **[3]**

[Total: 11]

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5 Ammonia, NH_3, and hydrazine, N_2H_4, are both bases.

(a) Ammonium sulfate, $(NH_4)_2SO_4$, can be prepared by reacting ammonia with sulfuric acid, H_2SO_4.

(i) Why can ammonium sulfate be described as a salt?

.....

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

(ii) A student was given 400 cm^3 of aqueous ammonia solution, $NH_3(aq)$. The student was asked to determine how many moles of NH_3 had been dissolved to prepare the solution.

The student titrated 25.0 cm^3 of $NH_3(aq)$ and found that it reacted exactly with 32.5 cm^3 of 0.100 mol dm^{-3} sulfuric acid.

The equation for this reaction is shown below.

$$2NH_3(aq) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(aq)$$

Calculate the amount, in moles, of NH_3 in the original 400 cm^3 solution.

answer = ... mol **[3]**

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(b) The hydrazine molecule, $H_2N–NH_2$, is covalent.

Predict the H–N–H bond angle in a hydrazine molecule.

Explain your answer.

.....

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

(c) Like ammonia, hydrazine is a base that reacts with water to form negative and positive ions.

(i) Write the formula of the negative ion that is formed when hydrazine reacts with water.

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

(ii) Suggest the formula of a positive ion which might form when hydrazine reacts with water.

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

TURN OVER FOR QUESTION 5(d)

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(d) Hydrazine, N_2H_4, has found a use as rocket fuel.

The overall equation for the production of hydrazine is shown below.

$$2NH_3 + NaCl O \rightarrow N_2H_4 + NaCl + H_2O$$

(i) Using oxidation numbers, explain why the above equation represents a redox reaction.

.....

.....

.....

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

(ii) What is the name for $NaCl O$?

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

(iii) The overall reaction takes place in two stages.

- In the first stage NH_2Cl is produced.
- In the second stage N_2H_4 is produced.

Some of the hydrazine reacts with NH_2Cl to form ammonium chloride and a colourless gas with a relative molecular mass of 28.0.

Construct the equation for this reaction.

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

[Total: 16]

END OF QUESTION PAPER

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RECOGNISING ACHIEVEMENT

GCE

Chemistry A

Advanced Subsidiary GCE

Unit **F321:** Atoms, Bonds and Groups

Mark Scheme for January 2012

Oxford Cambridge and RSA Examinations

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Annotations

Annotation	Meaning
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Ignore
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error
	Error in number of significant figures
	Correct response

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Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Subject-specific Marking Instructions

The following questions should be annotated with ticks to show where marks have been awarded in the body of the text: 3(d)(i), 3(d)(ii) and 4(b).

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<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td>(i)</td><td>mass of the isotope compared to 1/12th
OR
mass of the atom compared to 1/12th ✓

(the mass of a) ^{12}C (atom) ✓</td><td>2</td><td>ALLOW for ^{12}C: carbon-12 OR C-12 OR C 12 OR 12 C

IGNORE reference to average OR weighted mean
(ie correct definition of relative atomic mass scores both marks)

ALLOW mass of a mole of the isotope/atom with 1/12th ✓ the mass of a mole OR 12 g of carbon-12 ✓

ALLOW 2 marks for:
‘mass of the isotope OR mass of the atom compared to ^{12}C atom given a mass of 12.0’
ie ‘given a mass of 12’ communicates the same idea as 1/12th’

ALLOW FOR 2 MARKS:
$\frac{\text{mass of the isotope}}{\text{mass of 1/12th mass of carbon - 12}}$

ie fraction is equivalent to ‘compared to’

ALLOW 1 MARK FOR a mix of mass of atom and mass of mole of atoms, ie:
‘mass of the isotope/mass of an atom compared with 1/12th the mass of a mole OR 12 g of carbon-12’

DO NOT ALLOW mass of ion OR mass of element
BUT ALLOW mass of an atom of an element</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Both rows completed correctly ✓
<table><tr><th></th><th>protons</th><th>neutrons</th></tr><tr><td>iodine-127</td><td>53</td><td>74</td></tr><tr><td>iodine-131</td><td>53</td><td>78</td></tr></table></td><td>1</td><td>ALL four entries in table correct for 1 mark</td></tr>
</table>

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Question			Answer	Marks	Guidance
1	(b)	(i)	FIRST CHECK THE ANSWER ON ANSWER LINE IF answer = 91.6 (µg), must be 3 sf, award 2 marks Amount of I^- mark: = 70.0 x 10^{-6} /126.9 **OR** = 5.52 x 10^{-7} ✓ (mol) Mass of KI = (5.52 x 10^{-7}/10^{-6}) x 166.0 = 91.6 (µg) must be 3 sf ✓	2	If there is an alternative answer, check to see if there is any ECF credit possible **FOR ONE MARK ONLY** using working below **ALLOW** 70.0 x 10^{-x} /126.9 OR 5.52 x 10^{-x} (ie wrong conversion of µg and g) **ALLOW** calculator values which round to 5.52 x 10^{-x}, ie 3 significant figures or more **ALLOW** ECF for incorrect calculated amount of I^- x 166.0, must be 3 sf **ALLOW** calculator value or rounding to 3 significant figures or more **BUT IGNORE** 'trailing' zeroes, eg 0.200 allowed as 0.2. Answers with 91.6 x 10^{-x} (ie wrong conversion of µg and g) would get one mark
		(ii)	***Ethical implications*** Some people feel it is wrong to put additives into the national diet **OR** ***Dietary issues*** Food **OR** diet contains sufficient amounts of iodide ✓	1	**ALLOW** some people disapprove of additives in their food Assume 'it' refers to KI **IGNORE** economic reasons **ALLOW** (excess) potassium **OR** $K^{(+)}$ **OR** KI is harmful **OR** toxic **ALLOW too much** iodine **OR** iodide **OR** $I^{(-)}$is harmful **OR** toxic **ALLOW** iodine **OR** iodide **OR** $I^{(-)}$ **OR** KI is radioactive **ALLOW** any effect which would be detrimental to human health **OR** well-being **OR** eg 'lead to heart problems' **ALLOW** some table salt already contains iodide (eg sea salt) **ALLOW** some countries do not have (access to) KI **IGNORE** references to dangerous **OR** taste **IGNORE** responses referring solely to intake going above GDA **IGNORE** carcinogenic
	(c)	(i)	$Cl_2 + 2I^- \rightarrow 2Cl^- + I_2$ ✓	1	**IGNORE** state symbols

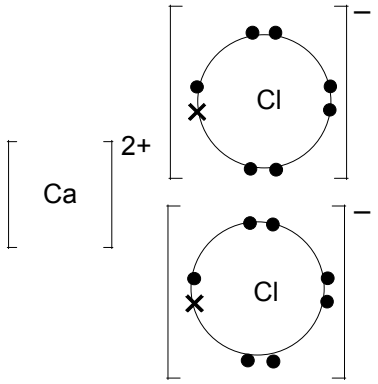
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Question			Answer	Marks	Guidance
1	(c)	(ii)	***Two alternative explanations to award the two marks:***	2	***Quality of Written Communication*:** **'dipole' OR 'permanent' spelled correctly at least once and in context for marking point 1 in explanation 1**
			Explanation 1 IC*l* has **permanent dipole** (–dipole) (interactions) **AND** Cl_2 has (only) van der Waals' forces ✓		**ALLOW** 'vdW' for van der Waals' **IGNORE** references to van der Waals' forces in IC*l* in explanation 1 **DO NOT ALLOW** 'dipole–dipole interactions' without reference to these being permanent for marking point 1
			Forces are stronger in IC*l* **ORA** **OR** More energy is needed to overcome forces in IC*l* ✓ **ORA**		**DO NOT ALLOW** marking point 2 for comparison of IC*l* having stronger ionic **OR** covalent bonds than Cl_2 ***Quality of Written Communication* – 'electrons' spelled correctly once and used in context for marking point 1 of explanation 2**
			Explanation 2 IC*l* has more electrons ✓ **ORA**		**ALLOW** I has more electrons
			Stronger van der Waals' forces in IC*l* (than in Cl_2) **ORA** **OR** More energy is needed to overcome van der Waals' forces in IC*l* ✓ **ORA**		**ALLOW** more van der Waals' forces **ALLOW** 'vdW' for van der Waals'
			Total	**9**	

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Question			Answer	Marks	Guidance
2	(a)		Add (aqueous) silver nitrate OR $AgNO_3$ **OR** Ag^+ ions ✓ white **AND** precipitate ✓	2	**IGNORE** references to nitric acid **DO NOT ALLOW** references to any other additional reagent added to silver nitrate for marking point 1 **ALLOW** 'solid' **OR** 'ppt' for 'precipitate'. Both colour **AND** state is needed. **IGNORE** references to solubility in ammonia for marking point 2 if colour of precipitate is stated **BUT** **ALLOW** 'dissolves in **dilute** ammonia' if **no** colour of precipitate is given **DO NOT ALLOW** marking point 2 if additional reagent leads to invalid test
	(b)		The mixture effervesced **OR** fizzed **OR** bubbled **OR** produced a **gas** ✓ **X** is $CaCO_3$ **OR** calcium carbonate ✓	2	**ALLOW** CaO would not fizz **IGNORE** name of gas
	(c)	(i)	Contains water (of crystallisation) ✓	1	**ALLOW** 'with water' **OR** 'has water' **DO NOT ALLOW** 'in solution' **OR** 'in water'
		(ii)	Working must be marked first 219.1 – 111.1 = 108 ✓ 108/18 (= 6) **AND** $CaCl_2 \cdot 6H_2O$ ✓	2	**ALLOW** $CaCl_2(H_2O)_6$ **ALLOW** $CaCl_2 6H_2O$ (ie no 'dot') **ALLOW** [219.1 – (40.1 + 2 x 35.5)] / 18 **AND** $CaCl_2 \cdot 6H_2O$ for two marks **ALLOW** ECF for incorrectly calculated mass of H_2O / 18 provided final answer is rounded to nearest whole number for marking point 2

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Question			Answer	Marks	Guidance
2	(d)		 Ca shown with either 8 or 0 electrons **AND** Cl shown with 8 electrons with 7 crosses and one dot (or *vice versa*) ✓ correct charges on both sets of ions ✓	2	**For first mark**, if eight electrons are shown in the cation then the 'extra' electron in the anion must match symbol chosen for electrons in the cation **IGNORE** inner shell electrons Circles **not** essential **ALLOW** One mark if both electron arrangement and charges are correct but only one Cl is drawn **ALLOW** $2[Cl^-]$ $2[Cl]^-$ $[Cl^-]_2$ (brackets not required) **DO NOT ALLOW** $[Cl_2]^-$ $[Cl_2]^{2-}$ $[2Cl]^{2-}$ $[Cl]_2^-$
	(e)		Ba is more reactive than Ca ✓ **ORA** Br_2 is less reactive than Cl_2 ✓ **ORA**	2	**ALLOW** reactivity increases down Group 2 **ORA** Provided Ca **and** Ba have been identified as Group 2 elements **ALLOW** reactivity decreases down Group 7 **ORA** Provided C*l* **and** Br have been identified as Group 7 elements **ALLOW** one mark for both sentences if no ascribing to groups **ALLOW** Br for Br_2 and C*l* for Cl_2 **DO NOT ALLOW** Br^- for Br_2 **OR** Cl^-
			Total	**11**	

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Question			Answer	Marks	Guidance
3	(a)	(i)	A region (within an atom) that can hold (up to) two electrons ✓ (with opposite spin)	1	**ALLOW** 'can be found' **OR** 'contains' **OR** 'has' etc. for 'can hold' **ALLOW** 'area' **OR** 'volume' **OR** 'space' **OR** 'somewhere' etc. for region **DO NOT ALLOW** path of an electron **IGNORE** references to 'orbitals being parts of sub-shells'
		(ii)	$1s^2 2s^2 2p^6 3s^2 3p^4$ ✓	1	**ALLOW** subscripts, capitals **IGNORE** $1s^2$ seen twice
		(iii)	7 ✓	1	
	(b)		(The amount of substance which contains) as many particles as there are carbon **atoms** in 12g of ^{12}C (atoms) ✓	1	**ALLOW** 6.02×10^{23} particles (atoms, molecules, ions etc.) **OR** N_A particles **OR** L particles **ALLOW** 'Avogadro number' in place of N_A particles **ALLOW** 'Number of atoms in 12 g of ^{12}C' **DO NOT ALLOW** 'the number of particles in 12g of ^{12}C atoms'
	(c)		Energy (needed) to remove an electron ✓ from **each atom** in **one mole** ✓ of **gaseous atoms** ✓	3	**ALLOW** 'Energy to remove one mole of electrons from one mole of gaseous atoms' for three marks **IGNORE** 'element' **ALLOW** 'Energy needed to remove an electron from one mole of gaseous atoms (to form one mole of gaseous 1+ ions') for two marks For third mark: **ALLOW** ECF if wrong 'particle' is used in second marking point but is described as being gaseous eg 'molecule' instead of 'atom' If no definition, **ALLOW** one mark for $X(g) \rightarrow X^+(g) + e^-$ **OR** $X(g) - e^- \rightarrow X^+(g)$ **ALLOW** e^- for electron **IGNORE** state symbols on e

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Question			Answer	Marks	Guidance
3	(d)	(i)	***From F to Ne*** *Nuclear charge mark:* Ne has (one) more proton **OR** Nuclear charge increases ✓ *Same shell or energy level mark:* (Outermost) electrons are in the same shell **OR** energy level **OR** (Outermost) electrons experience the same shielding ✓ *Nuclear attraction mark:* Greater nuclear attraction (on outermost electrons) **OR** Outer electrons are attracted more strongly (to the nucleus) ✓	3	**Use annotations with ticks, crosses, ECF etc for this part** **ALLOW** proton number increases but **IGNORE** atomic number increases **IGNORE** nucleus gets bigger **IGNORE** 'charge increases' ie must be nuclear charge **IGNORE** 'effective nuclear charge increases' **ALLOW** sub-shell for shell but **IGNORE** orbitals **ALLOW** shielding is similar **ALLOW** screening for shielding **IGNORE** Atomic radius decreases *(because given in question)* **OR** outermost electrons are closer **DO NOT ALLOW** 'distance is the same' for second mark **ALLOW** greater nuclear pull for greater nuclear attraction **DO NOT ALLOW** 'greater nuclear charge' instead of 'greater nuclear attraction' for the third mark **IGNORE** 'pulled closer' for 'pulled more strongly'
		(ii)	***From Ne to Na*** *Extra shell or energy level mark:* Na has (one) more shell(s) **OR** energy level ✓ *Shielding mark:* (Outermost) electron experiences greater shielding ✓ *Nuclear attraction mark:* Less nuclear attraction (on outermost electrons) **OR** Outer electrons are attracted less strongly (to nucleus) ✓	3	**Use annotations with ticks, crosses, ECF etc for this part** **ALLOW** 'next' shell **OR** 'new' shell **ALLOW** (outermost) electrons in a higher energy level **ALLOW** outermost electrons **OR** shell further from nucleus **IGNORE** Atomic radius increases *(because given in question)* **DO NOT ALLOW** orbitals **OR** sub-shells **ALLOW** screening for shielding **ALLOW** more electron repulsion from inner shells **ALLOW** 'less nuclear pull' for 'less nuclear attraction' **DO NOT ALLOW** 'less nuclear charge' for 'less nuclear attraction' for third mark. There must be a clear comparison
			Total	**13**	

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<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>4</td><td>(a)</td><td></td><td>
<table>
<tr><th>solid</th><th>melting point / ºC</th><th>type of lattice</th></tr>
<tr><td>K</td><td>63</td><td></td></tr>
<tr><td>KBr</td><td>734</td><td>giant ionic ✓</td></tr>
<tr><td>H_2O</td><td>0</td><td>simple molecular ✓</td></tr>
</table>
</td><td>2</td><td>giant AND ionic required

simple AND molecular required
ALLOW simple covalent</td></tr>
<tr><td></td><td>(b)</td><td></td><td>Particle mark 1:
In K, (electrostatic attraction between)
positive ions/cations AND e^- / electrons ✓

Particle mark 2:
In KBr, (electrostatic attraction between) oppositely OR
positively AND negatively charged ions ✓

Forces mark:
K has metallic bonding OR K has attraction between positive ions and electrons
AND
KBr has ionic bonding OR KBr has attraction between oppositely charged ions ✓

In H_2O,
Forces mark:
hydrogen bonding ✓

Particles mark (QWC):
(Between) molecules ✓

Order of strength of forces: KBr > K > H_2O
OR
ionic bonding > metallic bonding > hydrogen bonding ✓</td><td>6</td><td>Use annotations with ticks, crosses, ECF etc for this part

ALLOW labels from diagrams if not seen in text

ALLOW K^+ and Br^- for ‘oppositely charged ions’

DO NOT ALLOW ‘atoms’ in KBr

IGNORE ‘metallic lattice’ for metallic bonding’ AND ‘ionic lattice’ for ‘ionic bonding’
DO NOT ALLOW , for forces mark, incorrect forces for K and KBr, such as covalent, van der Waals’ seen anywhere in the response

IGNORE references to van der Waals’ forces in water

ALLOW ‘intermolecular’ OR ‘molecular’ for particles mark
Quality of Written Communication: ‘molecules’ OR ‘intermolecular’ OR ‘molecular’ spelt correctly once and used in context for the fifth marking point

The order of all three substances OR bonding must be referred to for this mark
ALLOW responses which use comparatives such as strong and extremely strong to differentiate strength of forces
ALLOW answers that inform KBr > K > H_2O IGNORING incorrect forces used above</td></tr>
</table>

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Question			Answer	Marks	Guidance
4	(c)		FIRST CHECK THE ANSWER ON ANSWER LINE IF answer = 72(.0) (cm^3) award 3 marks amount of K = 0.2346 / 39.1 **OR** = 6.(00) × 10^{-3} **OR** 0.006(00) mol ✓ amount of H_2 = (mol of K) / 2 **OR** = 3.(00) × 10^{-3} **OR** 0.003(00) mol ✓ Volume of gas = (mol of H_2) × 24000 **OR** = 72(.0) (cm^3) ✓	3	If there is an alternative answer, check to see if there is any ECF credit possible using working below **ALLOW** mol of K x 0.5 correctly calculated for 2nd mark **ALLOW** mol of H_2 x 24000 correctly calculated for 3rd mark **ALLOW** 144 (cm^3) from 0.006 x 24000 for two marks **ALLOW** 0.072 from 0.003 x 24 for two marks **ALLOW** calculator value or rounding to 2 significant figures or more **BUT IGNORE** 'trailing' zeroes, eg 0.200 allowed as 0.2
			Total	**11**	

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Question			Answer	Marks	Guidance
5	(a)	(i)	The H^+ **OR** hydrogen **ions OR** protons in (sulfuric) acid have been replaced by ammonium ions **OR** NH_4^+ ✓	1	**ALLOW** 'a positive ion' for 'ammonium ions' **BUT IGNORE** 'a positive metal ion' **OR** 'metal ions' for 'ammonium ions' **IGNORE** references to being produced by the reaction of an acid and a base **DO NOT ALLOW** hydrogen atoms **OR** ammonia ions **DO NOT ALLOW** 'H for H^+ OR NH_4 for NH_4^+
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE IF answer = 0.104 (mol) award 3 marks Amount of H_2SO_4 = 0.100 × 32.5/1000 = 3.25 × 10^{-3} **OR** 0.00325 mol ✓ Amount of NH_3 = (mol of H_2SO_4) × 2 = 6.50 × 10^{-3} **OR** 0.0065 mol ✓ No. of mol of NH_3 = (mol of NH_3) × 400 / 25.0 = 0.104 (mol) ✓	3	If there is an alternative answer, check to see if there is any ECF credit possible using working below **ALLOW ECF** for amount of H_2SO_4 × 2 **ALLOW ECF** for amount of NH_3 × 400 / 25.0 **ALLOW** concentration approach for marking point 3 Conc ammonia = 6.50 × 10^{-3} x 1000 / 25.0 = 0.260 mol dm^{-3} mol of NH_3 = (conc of NH_3) × 400 / 1000 = 0.104 (mol) **ALLOW** calculator value or rounding to 2 sig figs or more **BUT IGNORE** 'trailing' zeroes, eg 0.200 allowed as 0.2
	(b)		Predicted bond angle 107º ✓ *Explanation* There are 3 bonded pairs **and** 1 lone pair ✓ Electron **pairs** repel ✓ Lone pairs repel more than bonded pairs ✓	4	**ALLOW** range 106–108º **ALLOW** a response which is equivalent to 3 bp and 1 lp, eg 'There are four pairs of electrons. One is a lone pair' **ALLOW** 'bonds' for 'bonded pairs' **ALLOW** diagram showing N atom with 3 dot-and-cross bonds and 1 lone pair clearly drawn onto it for second mark **IGNORE** stick versions of bonding **DO NOT ALLOW** 'atoms repel' for 'electron pairs repel' **IGNORE** 'electrons repel' **ALLOW** 'bonds repel'

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Question			Answer	Marks	Guidance
5	(c)	(i)	OH^- ✓	1	Correct charge must be seen **ALLOW** OH^- if seen as the ONLY negative product of an equation
		(ii)	$N_2H_5^+$ **OR** $N_2H_6^{2+}$ ✓	1	**ALLOW** $H_2N–NH_3^+$ **OR** $H_3N–NH_3^{2+}$
	(d)	(i)	C*l* goes from (+)1 to –1 ✓	3	**ALLOW** 1(+), 1–. Only look for oxidation numbers seen above or below equation if not seen in text **IGNORE** Cl^- Cl^+ **DO NOT ALLOW** If a second species is seen going down in oxidation number with the exception of N going from –3 to –4
			N goes from –3 to –2 ✓		**ALLOW** 3 –, 2 –. Only look for oxidation numbers seen above or below equation if not seen in text **IGNORE** N^{3-} N^{2-} **DO NOT ALLOW** If a second species is seen going up in oxidation number
			C*l* is reduced **AND** N is oxidised ✓		**ALLOW** ECF for oxidation of any species showing an increase in oxidation number **AND** for reduction of any species showing a decrease in oxidation number **IGNORE** references to electron loss **OR** gain **ALLOW** 3 marks for labelled equation such as below $2NH_3 + NaClO \rightarrow N_2H_4 + NaCl + H_2O$ –3 +1 –2 –1 oxidation reduction
		(ii)	sodium chlorate(I) ✓	1	**ALLOW** sodium chlorate I (ie no brackets) **ALLOW** sodium hypochlorite **IGNORE** bleach **DO NOT ALLOW** sodium chlorate (with no Roman numeral)
		(iii)	$N_2H_4 + 2NH_2Cl \rightarrow 2NH_4Cl + N_2$ ✓✓	2	One mark for N_2 One mark for NH_4Cl **AND** balancing
			Total	**16**	

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ADVANCED SUBSIDIARY GCE

CHEMISTRY A

Atoms, Bonds and Groups

F321

Candidates answer on the question paper.

OCR supplied materials:
- *Data Sheet for Chemistry A* (inserted)

Other materials required:
- Scientific calculator

Monday 23 May 2011
Afternoon

Duration: 1 hour

F3185101611

F 3 2 1

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The insert will be found in the centre of this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.
- Answer **all** the questions.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
-  Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry A* 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**.
- This document consists of **16** pages. Any blank pages are indicated.

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Answer **all** the questions.

1 This question is about a model of the structure of the atom.

(a) A model used by chemists includes the relative charges, the relative masses and the distribution of the sub-atomic particles making up the atom.

Complete the table below.

particle	relative charge	relative mass	position within the atom
proton			
neutron			
electron		1/2000	shell

[1]

(b) Early studies of ionisation energies helped scientists to develop a model for the electron structure of the atom.

Define the term *first ionisation energy*.

.....

.....

.....

.....

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

(c) A modern model of the atom arranges electrons into orbitals, sub-shells and shells.

Complete the following table showing the maximum number of electrons which can be found within each region.

region	number of electrons
a 2p orbital	
the 3s sub-shell	
the 4th shell	

[3]

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(d) The modern Periodic Table arranges the elements in order of their atomic number. When arranged in this order the elements show periodicity.

Explain what is meant by the term *periodicity*.

.....

.....

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

(e) In this part, you need to refer to the *Periodic Table of the Elements* in the *Data Sheet for Chemistry A*.

From the first 18 elements **only**, choose an element which fits the following descriptions.

(i) An element with an isotope that can be represented as $^{14}_{6}X$. ..... **[1]**

(ii) The element which has the strongest metallic bonding in Period 3. ..... **[1]**

(iii) The element which forms a 3– ion with the same electron structure as Ne. ..... **[1]**

(iv) The element which has the smallest third ionisation energy. ..... **[1]**

(v) The element with the first six successive ionisation energies shown below, in $kJ\,mol^{-1}$.

738 1451 7733 10541 13629 17995

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

[Total: 13]

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2 Magnesium is the eighth most abundant element in the Earth's crust and many rocks are a source of magnesium compounds.

Magnesium carbonate, $MgCO_3$, is present in dolomite, a rock found in the Dolomite mountains in Italy.

A student collected two equal-sized samples of dolomite. These samples were put into two labelled test-tubes, **A** and **B**. Tube **A** was heated until there was no further change in mass and was then allowed to cool. Tube **B** was left unheated.

(a) Write the equation for the action of heat on the magnesium carbonate present in tube **A**.

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

(b) The student wanted to make magnesium chloride crystals. The student added an excess of warm dilute hydrochloric acid to tube **A** and to tube **B**.

(i) Write the equation for the reaction of magnesium carbonate in tube **B** with dilute hydrochloric acid.

Include state symbols.

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

(ii) State **one** similarity and **one** difference the student would see between the reactions in the two tubes.

similarity .....

.....

difference .....

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

(iii) From the solution in each tube, the student obtained crystals with the formula $MgCl_2 \bullet 6H_2O$.

Calculate the relative formula mass of $MgCl_2 \bullet 6H_2O$.

Give your answer to **one** decimal place.

relative formula mass = ... **[1]**

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(iv) Draw a *'dot-and-cross'* diagram to show the bonding in $MgCl_2$.

Show **outer** electrons only.

[2]

(c) A compound containing magnesium, silicon and oxygen is also present in rock types in Italy. A sample of this compound weighing 5.27 g was found to have the following composition by mass:

Mg, 1.82 g; Si, 1.05 g; O, 2.40 g.

Calculate the empirical formula of the compound.

Show your working.

empirical formula = ... **[2]**

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(d) Pharmacists sell tablets containing magnesium hydroxide, $Mg(OH)_2$, to combat indigestion.

A student carried out an investigation to find the percentage by mass of $Mg(OH)_2$ in an indigestion tablet. The student reacted the tablet with dilute hydrochloric acid.

$$Mg(OH)_2(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + 2H_2O(l)$$

The student found that 32.00 cm^3 of 0.500 mol dm^{-3} HCl was needed to react with the $Mg(OH)_2$ in a 500 mg tablet. [1 g = 1000 mg].

(i) Calculate the amount, in mol, of HCl used.

amount = ... mol **[1]**

(ii) Determine the amount, in mol, of $Mg(OH)_2$ present in the tablet.

amount = ... mol **[1]**

(iii) Determine the percentage by mass of $Mg(OH)_2$ present in the tablet.

answer = ... % **[3]**

[Total: 15]

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3 The chlor-alkali industry is an important part of the UK chemical industry.

The raw material is brine, a concentrated aqueous solution of sodium chloride, NaCl(aq). Two products that can be manufactured from brine are chlorine and sodium hydroxide — hence the name chlor-alkali.

(a) Bleach can be made by reacting chlorine with cold aqueous sodium hydroxide. A solution of bleach contains the chlorate compound NaClO.

Write the equation for the reaction taking place.

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

(b) The systematic name for NaClO is sodium chlorate(I). Other chlorate compounds exist, such as $NaClO_3$.

(i) Give the systematic name for $NaClO_3$.

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

(ii) When heated, $NaClO_3$ disproportionates as shown in the equation below.

$$4NaClO_3 \longrightarrow 3NaClO_4 + NaCl$$

Using oxidation numbers, explain why this is a disproportionation reaction.

.....

.....

.....

.....

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

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(c) Chlorine has been added to drinking water for over a century. Recently, some scientists have put forward the case for **not** chlorinating drinking water. This is because chlorine may react with organic compounds in the water to form CH_3Cl.

(i) State **one** valid reason that supports the scientists' case and state **one** reason why chlorine should be added to drinking water.

.....

.....

.....

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

(ii) Draw a '*dot-and-cross*' diagram to show the bonding in a molecule of CH_3Cl.

Show **outer** electrons only.

[1]

(iii) Name the shape of a molecule of CH_3Cl .

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

(d) A sample of brine is a concentrated aqueous solution of sodium chloride, NaCl(aq).

Describe a simple chemical test that you could carry out to show that brine contains aqueous chloride ions. How would you confirm that no other halide ions are present?

Include an ionic equation in your answer.

.....

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

[Total: 13]

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4 Many metallic elements react with dilute hydrochloric acid to form a solution containing a salt.

(a) Zinc reacts with dilute hydrochloric acid to form a solution of the salt, zinc chloride, $ZnCl_2$.

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

(i) Explain why $ZnCl_2$ is a salt.

.....

.....

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

(ii) Predict the formula of the zinc salt that could be formed by adding an excess of zinc to phosphoric(V) acid, H_3PO_4.

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

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(b) Group 2 elements also react with dilute hydrochloric acid.

Describe **and** explain the trend in reactivity of the Group 2 elements with dilute hydrochloric acid as the group is descended.



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

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..... **[5]**

[Total: 7]

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5 Solids exist as lattice structures.

(a) Giant metallic lattices conduct electricity. Giant ionic lattices do not. If a giant ionic lattice is melted, the molten ionic compound will conduct electricity.

Explain these observations in terms of bonding, structure and particles present.

.....

.....

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

(b) The solid lattice structure of ammonia, NH_3, contains hydrogen bonds.

(i) Draw a diagram to show hydrogen bonding between **two** molecules of NH_3 in a solid lattice.

Include relevant dipoles and lone pairs.

[2]

(ii) Suggest why ice has a higher melting point than solid ammonia.

.....

.....

.....

.....

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

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(c) Solid SiO_2 melts at 2230 °C. Solid $SiCl_4$ melts at –70 °C. Neither of the liquids formed conducts electricity.

Suggest the type of lattice structure in solid SiO_2 and in solid $SiCl_4$ and explain the difference in melting points in terms of **bonding** and **structure**.

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

[5]

[Total: 12]

END OF QUESTION PAPER

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ADDITIONAL PAGE

If additional space is required, you should use the lined pages below. The question number(s) must be clearly shown.

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ADDITIONAL PAGE

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ADDITIONAL PAGE

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GCE

Chemistry A

Advanced Subsidiary GCE

Unit **F321:** Atoms, Bonds and Groups

Mark Scheme for June 2011

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All Examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the Report on the Examination.

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<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td></td><td>
<table>
<tr><td>particle</td><td>rel charge</td><td>rel mass</td><td>position</td></tr>
<tr><td>proton</td><td>+1</td><td>1</td><td>nucleus</td></tr>
<tr><td>neutron</td><td>nil/0</td><td>1</td><td>nucleus</td></tr>
<tr><td>electrons</td><td>-1</td><td>1/2000</td><td>in shells</td></tr>
</table>
✓</td><td>1</td><td>1 mark for whole table

ALLOW '+' on its own for rel charge of proton
DO NOT ALLOW '1' on its own for rel charge of proton
DO NOT ALLOW 'positive' for rel charge of proton

For neutron ALLOW 'neutral'

ALLOW '–' on its own for rel charge of electron
DO NOT ALLOW 'negative' for rel charge of electron

IGNORE '+' if precedes '1' for mass
IGNORE 'middle/centre' for nucleus</td></tr>
<tr><td></td><td>(b)</td><td></td><td>The energy required to remove an electron ✓

from each atom in one mole ✓

of atoms in the gaseous state ✓</td><td>1

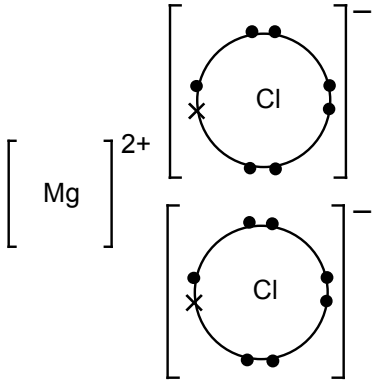
1

1</td><td>ALLOW 'energy to remove one mole of electrons from one mole of gaseous atoms' for three marks
ALLOW 'The energy required to remove an electron from one mole of gaseous atoms to form one mole of gaseous 1+ ions' for two marks as it does not meet the 2nd marking point

For third mark:
ALLOW ECF of wrong particle being gaseous

If no attempt at a definition, ALLOW one mark for the equation below, including state symbols
$X(g) \rightarrow X^+(g) + e^-$ OR $X(g) - e^- \rightarrow X^+(g)$
ALLOW e for electrons
IGNORE state symbol for electron</td></tr>
<tr><td></td><td>(c)</td><td></td><td>
<table>
<tr><td>a 2p orbital</td><td>2 ✓</td></tr>
<tr><td>the 3s sub-shell</td><td>2 ✓</td></tr>
<tr><td>the 4th shell</td><td>32 ✓</td></tr>
</table>
</td><td>1
1
1</td><td></td></tr>
<tr><td></td><td>(d)</td><td></td><td>A repeating pattern (of properties shown across different periods) ✓</td><td>1</td><td>ALLOW 'repeating trend'
DO NOT ALLOW just 'trend' OR 'pattern'</td></tr>
<tr><td></td><td>(e)</td><td>(i)</td><td>C ✓</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Al ✓</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>(iii)</td><td>N ✓</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>(iv)</td><td>Al ✓</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>(v)</td><td>Mg ✓</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>13</td><td></td></tr>
</table>

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Question			Answer	Mark	Guidance
2	(a)		$MgCO_3 \rightarrow MgO + CO_2$ ✓	1	**IGNORE** state symbols
	(b)	(i)	$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l) + CO_2(g)$ Correct balanced equation ✓ Correct states for correct species ✓	1 1	 **ALLOW** states mark if MgCl used in place of $MgCl_2$
		(ii)	Similarity: (Both) dissolve **OR** disappear. ✓ Difference: One effervesces **OR** fizzes **OR** bubbles **OR** gas produced ✓	1 1	**ALLOW** (both) 'go clear' **ALLOW** CO_2 produced **DO NOT ALLOW** incorrect gases **DO NOT ALLOW** responses which suggest **A** will effervesce e.g. as **B** will fizz more
		(iii)	203.3	1	**DO NOT ALLOW** 203 or 203.0 **IGNORE** units
		(iv)	 magnesium (ion) with 8 (or no) outermost electrons **AND** 2 x chloride (ions) with '*dot-and-cross*' outermost octet ✓ correct charges ✓	 1 1	**For 1st mark,** if 8 electrons shown around cation then 'extra' electron around anion must match symbol chosen for electrons in cation Shell circles not required **IGNORE** inner shell electrons **ALLOW** correct diagram of a $[Cl^-]$ ion with '2 x' **OR** '2' in front **OR** 'x 2' after the diagram. **ALLOW** correct diagram of $[Cl^-]$ ion with subscript 2. i.e. $[Cl^-]_2$. **DO NOT ALLOW** $[Cl^-_2]$ $[Cl]^-_2$ i.e. for first mark charges do not need to be seen

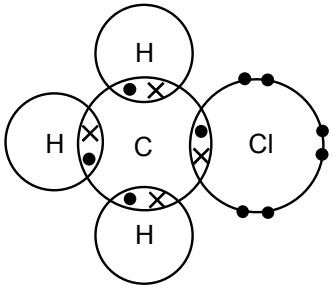
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Question			Answer	Mark	Guidance
2	(c)		$\frac{1.82}{24.3}$ $\frac{1.05}{28.1}$ $\frac{2.40}{16.0}$ To give 0.0749 0.0374 0.150 Ratio of moles ✓	1	**ALLOW** '24' for Mg (giving 0.0758) and '28' for Si (giving 0.0375) **ALLOW** any correct ratios of moles as calculator value **OR** correct rounding **to 2 sig figs or more** **ALLOW** method from masses being converted to percentages
			Answer = Mg_2SiO_4 ✓	1	**ALLOW** correct answer from a ratio of moles where it is clear that the candidate has divided by the atomic numbers. **ALLOW** ECF for formula from incorrect ratio of moles due to over-rounding calculator error or upside down mole calculation
	(d)	(i)	$\frac{32.00}{1000}$ x 0.500 = 1.60 x 10^{-2} (mol) **OR** 0.0160 (mol)✓	1	**ALLOW** 0.016 (mol) **IGNORE** trailing zeroes
		(ii)	$\frac{1.60 \times 10^{-2}}{2}$ = 8.00 x 10^{-3} (mol) **OR** 0.00800 (mol)✓	1	**ALLOW** ECF for answer **d(i)** / 2 **ALLOW** 0.008 or 8 × 10^{-3} (mol) Ignore trailing zeroes **ALLOW** 0.0080 or 8.0 × 10^{-3}
		(iii)	Molar mass $Mg(OH)_2$ = 58.3 ✓	1	**DO NOT ALLOW** 58 **OR** 58.0
			mass $Mg(OH)_2$ = 58.3 × 8.00 x 10^{-3} = 0.466(4) g ✓	1	**ALLOW** answer to **d(ii)** × 58.3 **ALLOW** 0.47 **ALLOW** ECF for **d(ii)** × incorrect molar mass as calculator value **OR** correct rounding to 2 sig figs or more
			% $Mg(OH)_2$ = $\frac{0.4664}{0.500}$ × 100 = 93.3% ✓	1	**ALLOW** 93% **OR** 93.2% **OR** 93.28% **DO NOT ALLOW d(ii)**/0.5 x 100 **ALLOW** (answer to second marking point/0.500) × 100 as calculator value **OR** correct rounding to 2 sig figs or more **ALLOW** moles method for 3 marks Molar mass = 58.3 0.500/58.3 = =0.00857(6) 0.00800/0857(6) × 100 = 93.3% **ALLOW** correct answer without working for 3 marks
			Total	**15**	

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Question			Answer	Mark	Guidance
3	(a)		$2NaOH + Cl_2 \rightarrow NaClO + NaCl + H_2O$ ✓	1	**ALLOW** NaOCl **IGNORE** state symbols
	(b)	(i)	Sodium chlorate(V) ✓	1	**ALLOW** sodium chlorate V **DO NOT ALLOW** sodium chlorate 5
		(ii)			***USE annotations with ticks, crosses, con, ECF, etc for this part.***
			Cl in $NaClO_3$ is (+)5 **AND** Cl in $NaClO_4$ is (+)7 **AND** Cl in NaCl is –1 ✓	1	**ALLOW** 5+, 7+ 1– Look for oxidation numbers seen above equation. **DO NOT ALLOW** Cl^- in NaCl
			Chlorine has been both oxidised and reduced **OR** The oxidation number of chlorine has increased **AND** decreased ✓	1	**The second and third marking points must refer to chlorine** **ALLOW** 'it' for 'chlorine' if oxidation numbers of chlorine are given **ALLOW** Cl for 'chlorine' **DO NOT ALLOW** Cl_2 for 'chlorine'
			Chlorine has been oxidised from (+)5 to (+)7 **AND** chlorine has been reduced from (+)5 to –1 ✓ (These points would secure marking points 2 and 3) $4NaClO_3 \rightarrow 3NaClO_4 + NaCl$ +5 +7 –1 oxidation reduction This diagram gets all 3 marks	1	**ALLOW** 'correct' references to oxidation and reduction even if based on incorrect oxidation numbers of chlorine **IGNORE** references to electron loss / gain if correct. **DO NOT ALLOW** 3rd mark for reference to electron loss/gain If oxidation numbers are correct, **ALLOW** 1 mark for 'chlorine is oxidised to form $NaClO_4$' **ALLOW** 1 mark for 'chlorine is reduced to form NaCl' **ALLOW** one mark for 'disproportionation is when a species is both oxidised and reduced' whether or not chlorine is mentioned
	(c)	(i)	Chlorinated hydrocarbons are carcinogens **OR** toxic **OR** Chlorine is toxic **OR** poisonous ✓	1	**ALLOW** CH_3Cl for 'chlorinated hydrocarbons' **IGNORE** 'harmful' **IGNORE** 'carcinogenic' for chlorine
			(Chlorine) kills bacteria **OR** 'kills germs' 'kills micro-organisms' **OR** 'makes water safe to drink' **OR** 'sterilises water' **OR** 'disinfects' ✓	1	**DO NOT ALLOW** 'antiseptic' **ALLOW** 'to make water potable' **ALLOW** 'removes' for 'kills' **IGNORE** 'virus' **IGNORE** 'purifies water' **IGNORE** 'cleans water'

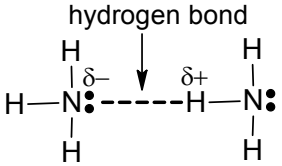
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Question			Answer	Mark	Guidance
3	(c)	(ii)	Electron pairs in covalent bonds shown correctly using dots and crosses in a molecule of CH_3Cl **AND** lone pairs correct on Cl ✓  	1	Must be '*dot-and cross'* **ALLOW** different symbol for third 'type' of electron Circles for outer shells not needed **IGNORE** inner shells Non-bonding electrons of chlorine do not need to be shown as pairs
		(iii)	Tetrahedral **OR** tetrahedron ✓	1	
	(d)		Add $AgNO_3$(aq) **OR** Ag^+(aq) **OR** silver nitrate **OR** $AgNO_3$ ✓	1	**ALLOW** Ag^+(aq) seen in the ionic equation **IGNORE** references to nitric acid **IGNORE** references to adding water or dissolving the brine **DO NOT ALLOW** references to any other additional reagent as well as the silver nitrate for the first mark
			White precipitate ✓	1	White **AND** precipitate required **DO NOT ALLOW** hint of any other colour **IGNORE** 'turns grey' **ALLOW** solid as alternative for precipitate
			$Ag^+ + Cl^- \rightarrow AgCl$ ✓	1	**IGNORE** states
			Add dilute NH_3 and precipitate (completely) dissolves **OR** disappears ✓	1	**DO NOT ALLOW** conc. NH_3 **DO NOT ALLOW** any mention of incomplete dissolving **ALLOW** (for 4th mark) 'add Cl_2(aq)' **AND** 'no colouration would be seen' **OR** 'no change' **OR** 'no reaction'
			Total	**13**	

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Question			Answer	Mark	Guidance
4	(a)	(i)	The hydrogen **ions OR** H^+ **OR** protons (of hydrochloric acid) are replaced by zinc **ions OR** Zn^{2+} ✓	1	**ALLOW** Zn ions **OR** positive ions replace H **ions OR** a metal ion has replaced a hydrogen ion **OR** protons **DO NOT ALLOW** Zn replaces H. Ions are key either in word form or symbol form **DO NOT ALLOW** Zn^+ i.e. if charge is shown it must be correct
		(ii)	$Zn_3(PO_4)_2$ ✓	1	**ALLOW** $ZnHPO_4$ **OR** $Zn(H_2PO_4)_2$ **ALLOW** $Zn_3P_2O_8$
	(b)				***USE annotations with ticks, crosses, con, ECF, etc for this part.***
			reactivity increases (down the group) ✓	1	'down the group' not required **ALLOW** alternative phrases for 'reactivity increases'
			Increasing size mark atomic radii increases **OR** there are more shells ✓	1	**ALLOW** 'there are more energy levels' **ALLOW** 'electrons are in a higher energy level' **ALLOW** 'the electrons are further from nucleus' **IGNORE** there are more orbitals **OR** more sub-shells **IGNORE** 'different shell' or 'new shell'
			Increased shielding mark there is **more** shielding ✓	1	**ALLOW** '**more** screening' There must be a clear comparison i.e. '**more** shielding' **OR** '**increased** shielding'. i.e. **DO NOT ALLOW** 'there is shielding' **ALLOW** 'there is **more** electron repulsion from inner shells' *'**more'** is essential*
			Nuclear attraction mark The nuclear attraction decreases **OR** (outermost) electrons experience less attraction (to nucleus) **OR** Increased shielding / distance outweighs the increased nuclear charge ✓	1	**ALLOW** 'there is less nuclear pull' **OR** 'electrons less tightly held' **IGNORE** 'there is less effective nuclear charge' **IGNORE** 'nuclear charge' for 'nuclear attraction'
			easier to remove (outer) electrons **OR** ionisation energy decreases ✓ **ORA** throughout	1	**ALLOW** 'easier to oxidise' ***Quality of Written Communication –*** *'electron(s)' **OR** 'ionisation' **OR** 'ionization' **OR** 'oxidise' **OR** oxidize' spelled correctly at least once for 5th marking point*
			Total	**7**	

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Question			Answer	Mark	Guidance
5	(a)		Metallic lattice has delocalised **OR** mobile electrons **OR** metallic bonding has delocalised **OR** mobile electrons ✓	1	**IGNORE** 'free electrons' for 'mobile electrons' **DO NOT ALLOW** references to incorrect bonding
			Ionic lattice has no mobile ions **OR** ionic solid has no mobile ions ✓	1	**ALLOW** 'ions are fixed in place' **IGNORE** 'no mobile electrons' for solid ionic **IGNORE** 'no mobile charge carriers' for solid ionic
			molten ionic (compounds) have mobile ions ✓	1	**IGNORE** 'delocalised ions' **OR** 'free ions' for 'mobile ions' **DO NOT ALLOW** any mention of electrons moving **IGNORE** 'aqueous ionic compounds have mobile ions'
	(b)	(i)	Two (or more) ammonia molecules with at least one Hδ+ and at least one Nδ- (can be on the same or different molecules) ✓	1	There must be 3H atoms bonded to one N atom **DO NOT ALLOW** any Hδ- **OR** Nδ+ **ALLOW** 2-D NH_3 molecules **IGNORE** lone pair(s) for first marking point
			H-bond between H in one ammonia and lone pair of N in another ammonia molecule ✓  	1	All H-bonds drawn must hit the lone pair H-bond does not need to be labelled but must be different from covalent bond **DO NOT ALLOW** more than one lone pair on N for second marking point **ALLOW** a pair of molecules with two 'correct' hydrogen bonds forming a 'dimer'
		(ii)	Ice has stronger hydrogen bonds ✓	1	**ALLOW** 'more' for 'stronger' **OR** Ice has twice as many hydrogen bonds as ammonia **ALLOW** ice has strong**er** intermolecular forces than ammonia **OR** big**ger** permanent dipole than ammonia **DO NOT ALLOW** comparisons between different types of force **DO NOT ALLOW** reference to van der Waals' **IGNORE** 'more energy needed'
			O has two lone pairs (**AND** N has one) **OR** O more electronegative (than N) ✓	1	**ALLOW** O has more lone pairs

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Question			Answer	Mark	Guidance
5	(c)				*USE annotations with ticks, crosses, con, ECF, etc for this part.*
			SiO_2 is **giant covalent** (lattice)✓	1	**ALLOW** macromolecular **OR** giant atomic **ALLOW** SiO_2 is a 'giant structure with covalent bonds' **ALLOW** even if reference to 'covalent' only appears later in answer. **DO NOT ALLOW** any reference to 'ionic' **OR** 'intermolecular' **OR** 'metallic' **Quality of Written Communication -** Covalent **OR** macromolecular **OR** atomic spelt correctly **ONCE** and used in context of the first marking point
			$SiCl_4$ is **simple molecular** (lattice) ✓	1	**ALLOW** simple covalent **DO NOT ALLOW** any reference to 'giant' **OR** 'ionic' **OR** 'metallic' **If neither of the 1st 2 marks have been awarded,** **ALLOW** 1 mark for SiO_2 is giant **AND** $SiCl_4$ is simple **OR** molecular
			van der Waals' forces in $SiCl_4$ ✓	1	**ALLOW** induced dipoles **DO NOT ALLOW** permanent dipoles
			Covalent bonds broken in SiO_2 ✓	1	**ALLOW** alternative words to broken e.g. overcome
			Forces **OR** bonds are stronger in SiO_2 (than in $SiCl_4$) **OR** more energy is needed to break forces **OR** bonds in SiO_2 (than in $SiCl_4$) ✓ **ORA**	1	**ALLOW** incorrect forces in $SiCl_4$ **OR** SiO_2 for this mark
			Total	**12**	

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RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

CHEMISTRY A

Atoms, Bonds and Groups

F321

Candidates answer on the question paper.

OCR supplied materials:
- *Data Sheet for Chemistry A* (inserted)

Other materials required:
- Scientific calculator

Thursday 13 January 2011
Morning

Duration: 1 hour

OCE/25757

F 3 2 1

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The insert will be found in the centre of this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Answer **all** the questions.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry A* 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**.
- This document consists of **12** pages. Any blank pages are indicated.

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Answer **all** the questions.

1 Sir Humphrey Davy, the inventor of the miners' safety lamp, was the first person to isolate the element strontium. Robert Bunsen, the inventor of the Bunsen burner, was partly responsible for the discovery of the element rubidium. Rubidium and strontium occur next to each other in the Periodic Table.

A sample of rubidium was analysed and found to consist of two isotopes, rubidium-85 and rubidium-87. Information about these isotopes is given in the table.

isotope	relative isotopic mass	abundance (%)
rubidium-85	85.00	72.15
rubidium-87	87.00	27.85

(a) In terms of sub-atomic particles, what is the difference between these isotopes of rubidium?

.....

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

(b) Define the term *relative atomic mass*.

.....

.....

.....

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

(c) Calculate the relative atomic mass of the sample of rubidium.

Give your answer to **two** decimal places.

answer = ... **[2]**

(d) Both rubidium, a Group 1 element, and strontium, a Group 2 element, have their outermost electrons in the 5s orbital.

What 3-D shape is the 5s orbital?

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

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(e) Ionisation energies allow chemists to determine electron structures. The first two ionisation energies of rubidium and strontium are shown in the table.

element	first ionisation energy / kJ mol^{-1}	second ionisation energy / kJ mol^{-1}
rubidium	403	2632
strontium	550	1064

(i) Write an equation to represent the **second** ionisation energy of strontium.

Include state symbols.

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

(ii) Why is the **first** ionisation energy of strontium larger than the **first** ionisation energy of rubidium?



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

.....

.....

.....

.....

.....

.....

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

(iii) Why is the **second** ionisation energy of rubidium larger than the **second** ionisation energy of strontium?

.....

.....

.....

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

[Total: 13]

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2 Sodium tartrate and copper(II) nitrate are both salts.

(a) Sodium tartrate is a salt of tartaric acid. The formula of tartaric acid can be represented as H_xA. In this formula, x is the number of H^+ ions that can be replaced by metal ions to form salts.

A student carries out a titration to find the value of x in the formula of tartaric acid, H_xA.
In the titration, 25.00 cm^3 of 0.0500 mol dm^{-3} tartaric acid, H_xA, exactly reacts with 12.50 cm^3 of 0.200 mol dm^{-3} sodium hydroxide, NaOH. A solution of sodium tartrate is produced.

(i) Calculate the amount, in mol, of H_xA used.

amount = ... mol **[1]**

(ii) Calculate the amount, in mol, of NaOH used.

amount = ... mol **[1]**

(iii) Deduce the value for x in the formula of tartaric acid, H_xA.

x = ... **[1]**

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(b) Copper(II) nitrate is a salt of nitric acid.

(i) A student prepares a solution of copper(II) nitrate, $Cu(NO_3)_2$, by adding, with stirring, an excess of copper(II) oxide to some hot dilute nitric acid.

Construct the equation for this reaction.

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

(ii) Copper(II) nitrate has ionic bonding.

What is meant by the term *ionic bonding*?

.....

.....

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

(iii) Explain why a solution of copper(II) nitrate conducts electricity.

.....

.....

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

(iv) What is the oxidation number of nitrogen in $Cu(NO_3)_2$?

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

(c) Hydrated crystals of copper(II) nitrate can be prepared by allowing water to evaporate from a solution of copper(II) nitrate.

Hydrated copper(II) nitrate has the empirical formula $CuN_2O_{12}H_{12}$.

Write the formula of hydrated copper(II) nitrate to show its water of crystallisation.

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

[Total: 9]

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3 Linus Pauling was a Nobel prize winning chemist who devised a scale of electronegativity.

Some Pauling electronegativity values are shown in the table.

element	electronegativity
B	2.0
Br	2.8
N	3.0
F	4.0

(a) What is meant by the term *electronegativity*?

.....

.....

.....

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

(b) Show, using δ+ and δ– symbols, the permanent dipoles on each of the following bonds.

N—F N—Br

[1]

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(c) Boron trifluoride, BF_3, ammonia, NH_3, and sulfur hexafluoride, SF_6, are all covalent compounds. The shapes of their molecules are different.

(i) State the shape of a molecule of SF_6.

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

(ii) Using outer electron shells only, draw *'dot-and-cross'* diagrams for molecules of BF_3 and NH_3.

Use your diagrams to explain why a molecule of BF_3 has bond angles of 120° and NH_3 has bond angles of 107°.

BF_3	**NH_3**

.....

.....

.....

.....

.....

.....

..... **[5]**

(iii) Molecules of BF_3 contain polar bonds, but the molecules are non-polar.

Suggest an explanation for this difference.

.....

.....

.....

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

[Total: 11]

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4 Calcium hydroxide is used in agriculture but the amounts used must be carefully controlled.

(a) State **one** use of calcium hydroxide in agriculture **and** suggest why the amount of calcium hydroxide used should not be excessive.

.....

.....

.....

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

(b) A student knew that calcium hydroxide could be made by adding calcium to water.

The student added 0.00131 mol of calcium to a beaker containing about 100 cm^3 of water.
A reaction took place as shown by the equation below.
All the calcium hydroxide formed was soluble.

$$Ca(s) + 2H_2O(l) \longrightarrow Ca(OH)_2(aq) + H_2(g)$$

(i) Calculate the mass of calcium that the student added.

mass of calcium = ... g **[1]**

(ii) Calculate the volume of hydrogen gas, in dm^3, produced in this reaction at room temperature and pressure, RTP.

volume of hydrogen gas = ... dm^3 **[1]**

(iii) The student transferred the contents of the beaker to a 250 cm^3 volumetric flask and water was added to make the solution up to 250 cm^3.

Calculate the concentration, in mol dm^{-3}, of **hydroxide ions** in the 250 cm^3 solution.

concentration = ... mol dm^{-3} **[2]**

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(c) The student repeated the experiment using the same mass of pure barium.

The student found that a smaller volume of hydrogen gas was produced, measured at RTP.

(i) Explain why.

.....

.....

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

(ii) Suggest **one** other difference the student would observe between the reactions of water with calcium and of water with barium.

.....

.....

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

[Total: 8]

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5 Chlorine, bromine and iodine are halogens commonly used in school and college experiments.

(a) Halogens have van der Waals' forces between their molecules.

(i) Describe how van der Waals' forces arise.

.....

.....

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

(ii) State **and** explain the trend in the boiling points of chlorine, bromine and iodine.

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

(b) The halogen astatine does **not** exist in large enough quantities to observe any of its reactions.

Why would astatine be expected to react similarly to other halogens?

.....

.....

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

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(c) A student investigated the reactivity of halogens by attempting some redox reactions.

(i) The student added bromine water to aqueous solutions of sodium chloride and sodium iodide in separate test-tubes. The student then added an organic solvent, cyclohexane, to each test-tube and these were shaken.

- State what colour you would see in the cyclohexane in each test-tube after shaking.
- Write **ionic** equations for any chemical reactions that take place.
- State and explain the trend in reactivity shown by these observations.



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

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

(ii) Suggest why the student carried out the reactions in a well ventilated area.

.....

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

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(d) The halogen fluorine is too reactive to use in a school or college laboratory. Fluorine is a powerful oxidising agent. It will react with water as shown below.

(i) Complete and balance the equation for the reaction of fluorine with water.

$F_2(g)$ + $H_2O(l)$ → ..... + $O_2(g)$ **[1]**

(ii) Using oxidation numbers, show what has been oxidised and what has been reduced in this reaction.

.....

.....

.....

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

(e) Fluorine will react violently with gallium to produce gallium fluoride.

Mendeleev originally called gallium 'eka-aluminium' as he predicted that gallium would have similar properties to aluminium.

(i) Complete the electron structure of the gallium atom.

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

(ii) Use Mendeleev's prediction to suggest the empirical formula of gallium fluoride.

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

[Total: 19]

END OF QUESTION PAPER

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GCE

Chemistry A

Advanced Subsidiary GCE

Unit **F321:** Atoms, Bonds and Groups

Mark Scheme for January 2011

Oxford Cambridge and RSA Examinations

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Question			Answer	Mark	Guidance
1	(a)		Rb-87 has (two) more neutrons ✓	1	**ALLOW** Different numbers of neutrons **ALLOW** 2 neutrons **ALLOW** Rb-85 has 48 neutrons **AND** Rb-87 has 50 neutrons **IGNORE** correct references to protons and electrons **DO NOT ALLOW** incorrect references to protons and electrons
	(b)		The (weighted) mean **mass** of an **atom** (of an element) **OR** The (weighted) average **mass** of an **atom** (of an element) ✓ compared with 1/12th (the mass) ✓ of (one atom of) carbon-12 ✓	3	**ALLOW** average atomic mass **DO NOT ALLOW** mean mass of an element **ALLOW** mean mass of isotope**s OR** average mass of isotope**s** **DO NOT ALLOW** the singular; 'isotope' For second **AND** third marking points **ALLOW** compared with (the mass of) carbon-12 which is 12 **ALLOW** mass of **one mole** of **atoms** ✓ compared to 1/12th ✓ (mass of) **one mole OR** 12 **g** of carbon-12 ✓ **ALLOW** mass of **one mole** of atoms 1/12th mass of **one mole** OR 12**g** of carbon-12
	(c)		$\frac{(85.00 \times 72.15) + (87.00 \times 27.85)}{100}$ = **OR** *61.3275 + 24.2295* **OR** *85.557* ✓ A_r = 85.56 (to 2 decimal places) ✓	2	**ALLOW** two marks for correct answer A_r = 85.56 (with no working) **ALLOW** one mark for **ECF** from **seen** incorrect sum provided final answer is between 85 and 87 and is to 2 decimal places, e.g. 85.567 gives **ECF** of 85.57 for one mark

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Question			Answer	Mark	Guidance
1	(d)		Spherical **OR** sphere ✓	1	**DO NOT ALLOW** 'circular' **IGNORE** unlabelled 2-D diagrams
	(e)	(i)	$Sr^{+}(g) \rightarrow Sr^{2+}(g) + e^{-}$ ✓	1	**ALLOW** e for electrons **ALLOW** $Sr^{+}(g) - e^{-} \rightarrow Sr^{2+}(g)$ **DO NOT ALLOW** $Sr^{+}(g) + e^{-} \rightarrow Sr^{2+}(g) + 2e^{-}$ **IGNORE** state symbols for electrons
	(e)	(ii)		3	**Use annotations with ticks, crosses ECF etc. for this part**
			Sr has one **more** proton **OR** greate**r** nuclear charge ✓		Comparison should be used for each mark **ALLOW** Sr has more protons **ALLOW** 'across the period' for 'Sr' **IGNORE** 'atomic number increases', but **ALLOW** 'proton number' increases **IGNORE** 'nucleus gets bigger' 'Charge increases' is insufficient **ALLOW** 'effective nuclear charge increases' **OR** 'shielded nuclear charge increases' ***Quality of Written Communication –*** *Nuclear* ***OR*** *proton(s)* ***OR*** *nucleus spelled correctly* ***ONCE*** *for the* ***first*** *marking point*
			(Outermost) electrons are in the same shell **OR** (outermost) electrons experience same shielding **OR** Atomic radius of Sr is small**er** ✓		**ALLOW** shielding is similar **ALLOW** screening for shielding **IGNORE** sub-shells **DO NOT ALLOW** 'distance is similar'
			Sr has greate**r** nuclear attraction (on outer electrons / outer shell/s) **OR** the (outer) electrons are attracted more strongly (to the nucleus) ✓		**ALLOW** 'greater nuclear pull' for 'greater nuclear attraction' **DO NOT ALLOW** 'nuclear charge' for nuclear attraction **ORA** throughout

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Question			Answer	Mark	Guidance
1	(e)	(iii)	2nd IE of Rb involves removing electron from shell closer to nucleus ✓ Strong**er** nuclear attraction on (outermost electron) of Rb **OR** (outermost electron) of Rb experiences **less** shielding ✓	2	**IGNORE** new shell **ALLOW** There is one shell fewer in $Rb^{(+)}$ (than Sr^{+}) **ALLOW** $Rb^{(+)}$ has a smaller radius (than Sr^{+}) **ALLOW** $Rb^{(+)}$ loses an electron from the 4th shell **AND** $Sr^{(+)}$ loses an electron from the 5th shell. **ALLOW** responses which do not specifically say 'nuclear' attraction (e.g. Rb has greater attraction) as long as nucleus is seen in first point A comparison of Rb to Sr must be used, e.g. 'Because of shielding' is not enough **ORA**
			Total	**13**	

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Question			Answer	Mark	Guidance
2	(a)	(i)	mol of H_xA = $\frac{25.00 \times 0.0500}{1000}$ = 1.25×10^{-3} **OR** 0.00125 mol ✓	1	**ALLOW** 0.0013 **OR** 1.3×10^{-3} **ALLOW** correct answer only without working
		(ii)	mol of NaOH = $\frac{12.50 \times 0.200}{1000}$ = 2.5(0) × 10^{-3} **OR** 0.0025(0) mol ✓	1	**ALLOW** correct answer without working
		(iii)	Answer **2a(ii)** rounded to nearest whole number ✓ Answer **2a(i)** If **2a(i)** and **2a(ii)** are correct this will be $x = \frac{2.50 \times 10^{-3} \text{ mol}}{1.25 \times 10^{-3} \text{ mol}} = 2$ **OR** H_2A	1	**ALLOW** answer without working if answers to **2a(i) AND 2a(ii)** are seen **DO NOT ALLOW** responses without seeing answers in **2a(i) AND 2a(ii)**
	(b)	(i)	HNO_3 ✓ $CuO + 2HNO_3 \rightarrow Cu(NO_3)_2 + H_2O$ ✓	2	**IGNORE** state symbols **ALLOW** correct multiples
		(ii)	(Electrostatic) **attraction** between **oppositely** charged **ions** ✓	1	**Attraction** is essential **IGNORE** references to metal and non-metal
		(iii)	**Ions** are mobile **OR** ions can move ✓	1	**IGNORE** 'free ions' **IGNORE** 'delocalised ions' **IGNORE** ions can move when molten **IGNORE** charge carriers **DO NOT ALLOW** Any mention of electrons moving **ALLOW** ions move when **in** a liquid **IGNORE** responses which give liquid ions
		(iv)	(+) 5 ✓	1	**ALLOW** V

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Question			Answer	Mark	Guidance
2	(c)		$Cu(NO_3)_2 \cdot 6H_2O$ ✓	1	**ALLOW** $Cu(NO_3)_2 6H_2O$ **ALLOW** $Cu(NO_3)_2(H_2O)_6$ **ALLOW** $Cu(NO_3)_2.6H_2O$ **DO NOT ALLOW** $CuN_2O_6 \cdot 6H_2O$
			Total	**9**	

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Question			Answer	Mark	Guidance
3	(a)		The ability of an **atom** to attract electrons ✓ in a covalent bond ✓	2	**ALLOW** 'attraction of an **atom** for electrons' **ALLOW** 'pull' for 'attract' **DO NOT ALLOW** 'element' for 'atom' **ALLOW** 'shared pair' or 'bond(ing) pair' for 'covalent bond'
	(b)		δ^+N–Fδ^- **AND** δ^-N–Brδ^+ ✓	1	**ALLOW** d+ / d- **DO NOT ALLOW** + / –
	(c)	(i)	octahedral **OR** octahedron ✓	1	
		(ii)	 Diagram of BF_3 showing three '*dot-and-cross*' bonds between B and F and all F atoms with complete octet of electrons ✓ Diagram of NH_3 showing three '*dot-and-cross*' bonds between N and H and N atom has a lone pair ✓ ***Marking points 3, 4 and 5 may be awarded independently*** electron pairs repel ✓ NH_3 has **one lone** pair and **three bonding** pairs of electrons **AND** lone pair of electrons repels **more** than bonding pairs ✓ BF_3 has **three** (bonding) pairs of electrons (which repel equally) ✓	5	**Use annotations with ticks, crosses ECF etc. for this part** **ALLOW** diagrams without circles Must be '*dot-and-cross*' **IGNORE** 'electrons repel' **DO NOT ALLOW** 'atoms repel' **ALLOW** 'bonds repel' **ALLOW** 'bonds' for 'bonding pairs' **ALLOW** 'four pairs' in place of 'one lone pair and three bonding pairs' The third marking point can be gained from statements seen in fourth or fifth marking points

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Question			Answer	Mark	Guidance
3	(c)	(iii)	BF_3 is **symmetrical** ✓ The **dipoles** cancel out ✓	2	**IGNORE** 'polar bonds cancel' **IGNORE** 'charges cancel'
			Total	**11**	

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Question			Answer	Mark	Guidance
4	(a)		Used to neutralise **acidic** soils ✓ Excess will result in soils becoming **too** alkaline (to sustain crop growth) ✓	2	**ALLOW** raises the pH of the soil **IGNORE** references to fertilisers **ALLOW** pH becomes **too** high **IGNORE** 'harmful' **IGNORE** 'corrosive'
	(b)	**(i)**	0.00131 × 40.1 = 0.0525 g **OR** 5.25×10^{-2} ✓	1	**ALLOW** 0.053 **OR** 0.05253 **OR** 0.052531 g **IGNORE** 0.05 **if correct answer seen in working** **DO NOT ALLOW** 0.052 **OR** 0.0524
		(ii)	0 00131 × 24.0 = 0.0314 dm^3 **OR** 3.14×10^{-2} ✓	1	**ALLOW** 0.031 **OR** 0.03144 dm^3 **IGNORE** 0.03 **if correct answer seen in working** **DO NOT ALLOW** 31.4
		(iii)	Mol of OH^- ions = 0.00131 × 2 = 0.00262 **OR** 2.62×10^{-3} ✓ Mol of OH^- ions in 1 dm^3 = $0.00262 \times \frac{1000}{250}$ = 0.0105 mol dm^{-3} ✓	2	**ALLOW** 0.0026 **ALLOW** 0.01048 **OR** 0.01(0) **ALLOW ECF** from incorrect mol of OH^- **DO NOT ALLOW** 2nd mark as **ECF** if 0.0525 is used as no of mol of OH^- ions **DO NOT ALLOW** 2nd mark as **ECF** if 0.0314 is used as no of mol of OH^- ions 0.00524 mol dm^{-3} is a likely **ECF** as a result of not multiplying 0.00131 by 2, but 0.00131 must be seen in working
	(c)	**(i)**	**Fewer** moles of Ba (in 0.0525 g) **OR Fewer** atoms of Ba (in 0.0525) ✓	1	**ORA** Assume candidate is referring to Ba if not stated **IGNORE** A_r Ba > A_r Ca
		(ii)	Idea of Ba having a quick**er** rate **OR more** vigorous reaction ✓	1	**ALLOW more** exothermic **OR** gets hot**ter OR** fizzes more Assume candidate is referring to Ba if not stated Comparison is essential **IGNORE** 'Ba more reactive' **ORA**
			Total	**8**	

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Question			Answer	Mark	Guidance
5	(a)	(i)	***Creating the dipole mark*** uneven distribution of electrons ✓ ***Type of dipole mark*** creates an instantaneous dipole **OR** temporary dipole ✓ ***Induction of a second dipole mark*** causes induced dipole(s) in neighbouring molecules ✓	3	**Use annotations with ticks, crosses ECF etc. for this part** **ALLOW** movement of electrons **ALLOW** changing electron density **ALLOW** 'transient', 'oscillating', 'momentary', 'changing' **ALLOW** 'induces a dipole in neighbouring molecules' **ALLOW** 'causes a resultant dipole in neighbouring molecules' **ALLOW** 'atoms' for 'molecules'
		(ii)	boiling points increase down the group ✓ greater number of electrons **OR** stronger intermolecular forces **OR** stronger van der Waals' forces ✓ more energy needed to break intermolecular **OR** van der Waals' forces ✓	3	**Use annotations with ticks, crosses ECF etc. for this part** **ALLOW** Bpt of iodine is high**est OR** Bpt of chlorine is low**est** **ALLOW** Cl for chlorine etc. For 'down the group' **ALLOW** 'as molecules get bigger' **ALLOW** number of **electron** shells increases **IGNORE** 'more shells' (if no reference to electrons) **ALLOW** 'more' for 'stronger' **ALLOW** iodine has most electrons **ALLOW** chlorine has fewest electrons **DO NOT ALLOW** any implication that the attraction is between atoms not molecules for third mark
	(b)		Same number of **outer(most)** electrons **OR** same **outer(most)** electron structure ✓	1	**ALLOW** same number of electrons in outer shell **ALLOW** It has seven outer electrons **IGNORE** same group **DO NOT ALLOW** 'same number of electrons'

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Question			Answer	Mark	Guidance
5	(c)	(i)	***Colours:***	6	**Use annotations with ticks, crosses ECF etc. for this part**
			(Add Br_2 to NaCl,) (Cyclohexane layer) turns orange **OR** yellow ✓		**ALLOW** any combination of these but no others
			(Add Br_2 to NaI,) (Cyclohexane layer) turns purple **OR** lilac **OR** violet **OR** pink **OR** mauve ✓		**ALLOW** any combination of these but no others **DO NOT ALLOW** 'precipitate' with either colour
			Equation:		**DO NOT ALLOW** equation mark if incorrect equation(s) also seen
			$Br_2 + 2I^- \rightarrow I_2 + 2Br^-$ ✓		**IGNORE** $Br_2 + 2Cl^- \rightarrow Br_2 + 2Cl^-$ **IGNORE correct** non-ionic version of equation **IGNORE** state symbols
			Reactivity:		
			Reactivity decreases down the group **OR** Oxidising power decreases down the group ✓		**ALLOW** Chlorine is the most reactive **ALLOW** Cl for chlorine etc. **ALLOW** Iodine is the least reactive
			Explanations:		
			Chlorine will gain electron easiest **OR** form negative ion easiest ✓		**ALLOW** chlorine is best at electron capture **ALLOW** chlorine has 'greatest' electron affinity **IGNORE** chlorine is most electronegative **DO NOT ALLOW** explanations in terms of displacement ***Quality of Written Communication –*** *Electron(s)* ***OR*** *negative spelled correctly at least* ***ONCE*** *for marking point 5*
			Because chlorine (atom) is smallest **OR** Outer(most) shell of chlorine least shielded **OR** Nuclear attraction on electrons of chlorine is greatest ✓		**ALLOW** Chlorine atom has fewest shells **ALLOW** outer(most) shell closest to the nucleus **ALLOW** Chlorine atom has lowest shielding **ORA** for marking points 4, 5 and 6

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Question			Answer	Mark	Guidance
5	(c)	(ii)	Bromine is toxic ✓	1	**ALLOW** cyclohexane is toxic **ALLOW** bromine irritates the lungs **DO NOT ALLOW** Cl_2 is toxic **IGNORE** 'strong smelling' **IGNORE** 'halogens' are toxic
	(d)	(i)	$2F_2 + 2H_2O \rightarrow 4HF + O_2$ ✓	1	**ALLOW** correct multiples, including use of ½ O_2 **ALLOW** 4FH **IGNORE** state symbols
		(ii)	Oxygen has been oxidised as (oxidation number has increased from) O = –2 to O = 0 ✓ Fluorine has been reduced as (oxidation number has decreased from) F = 0 to F = –1 ✓	2	**IGNORE** references to oxygen in any incorrect products **DO NOT ALLOW** O_2 = –2 → O = 0 but **ALLOW** F_2 = 0 → F = –1 **ALLOW** 'F is reduced from 0 to –1' regardless of product (or no product) in **5d(i)** except **ALLOW ECF** for F = –2 **if** H_2F is seen **ALLOW** one mark for O = –2 and O_2 = 0 **AND** F_2 = 0 and F = –1 if **no reference OR incorrect reference** to oxidation / reduction is seen Look at equation in **5d(i)** for oxidation numbers **if not seen in 5d(ii)** **IGNORE** reference to electron loss / gain if correct **DO NOT ALLOW** incorrect reference to electron loss / gain
	(e)	(i)	$(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^1$ ✓	1	**IGNORE** $1s^2$ twice **ALLOW** $4s^2$ before $3d^{10}$ **ALLOW** '3D'
		(ii)	GaF_3 ✓	1	
			Total	**19**	

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THIS IS A NEW SPECIFICATION

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ADVANCED SUBSIDIARY GCE
CHEMISTRY A
Atoms, Bonds and Groups

F321

Candidates answer on the Question Paper

OCR Supplied Materials:
- *Data Sheet for Chemistry A* (inserted)

Other Materials Required:
- Scientific calculator

Friday 21 May 2010
Afternoon

Duration: 1 hour

OCE/22845

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry A* 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**.
- This document consists of **16** pages. Any blank pages are indicated.

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Answer **all** the questions.

1 Tin mining was common practice on Dartmoor in pre-Roman times. Most of the tin extracted was mixed with copper to produce bronze.

(a) The table below shows the sub-atomic particles of an isotope of tin.

isotope	protons	neutrons	electrons
^{118}Sn			

(i) Complete the table. **[1]**

(ii) In terms of sub-atomic particles, how would atoms of ^{120}Sn differ from atoms of ^{118}Sn?

.....

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

(b) The relative atomic mass of tin is 118.7.

Define the term *relative atomic mass*.

.....

.....

.....

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

(c) A bronze-age shield found on Dartmoor contained 2.08 kg of tin.

Calculate the number of tin atoms in this bronze shield.
Give your answer to **three** significant figures.

answer = ... **[2]**

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(d) Tin ore, known as cassiterite, contains an oxide of tin. This oxide contains 78.8% tin by mass. Calculate the empirical formula of this oxide. You must show your working.

answer = ... **[2]**

[Total: 9]

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2 Chemicals called 'acids' have been known throughout history. The word acid comes from the Latin 'acidus' meaning sour. Dilute sulfuric acid, H_2SO_4, is a common laboratory acid.

(a) (i) State the formulae of two ions released when sulfuric acid is in aqueous solution.

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

(ii) A student adds a sample of solid potassium carbonate, K_2CO_3, to an excess of dilute sulfuric acid.

Describe what the student would **see** and write the equation for the reaction which takes place.

.....

.....

.....

.....

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

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(b) Dilute sulfuric acid reacts with alkalis such as sodium hydroxide.

Solid sodium hydroxide is known as caustic soda. It has a household use as a drain cleaner.

A student believes a box of caustic soda has been accidentally contaminated.

- To prove this, the student dissolves 2.00 g of the impure caustic soda in water and the solution is made up to 250 cm^3.
- 25.0 cm^3 of this solution of caustic soda is neutralised by 24.60 cm^3 of 0.100 mol dm^{-3} dilute sulfuric acid.

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

(i) Calculate the amount, in moles, of H_2SO_4 used.

answer = ... mol **[1]**

(ii) Determine the amount, in moles, of NaOH in the 25.0 cm^3 used.

answer = ... mol **[1]**

(iii) Calculate the percentage, by mass, of NaOH in the impure caustic soda.

answer = ... **[3]**

[Total: 10]

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3 In an atom the electrons occupy sub-shells in order of increasing energy.

(a) Complete the table below to show the order in which the next two sub-shells are filled.

1s	2s	2p	3s	3p	4s		

increasing energy $\longrightarrow$

[1]

(b) Sub-shells are made up of orbitals.

(i) What is meant by an *orbital*?

.....

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

(ii) State the total number of electrons occupying the p orbitals in one chlorine atom.

answer = ... **[1]**

(c) How many electrons are there in one ion of Ca^{2+}?

answer = ... **[1]**

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(d) The successive ionisation energies of aluminium are shown in the table below. Some of these ionisations involve the removal of an electron from an s sub-shell.

ionisation energy / kJ mol^{-1}	578	1817	2745	11 578	14 831	18 378	23 296	27 460	31 862	38 458	42 655
ionisation number	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th

(i) State **all** the ionisation numbers that involve the removal of an electron from s sub-shells.

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

(ii) Write the equation that represents the third ionisation energy of A*l*.
Include state symbols.

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

[Total: 8]

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4 In the Periodic Table, the chemistry of elements in a group can often be predicted from the chemistry of just one element in the group.

(a) Ions of Group 7 elements take part in displacement reactions. These reactions can be used to compare the reactivities of the elements within Group 7.

A student adds aqueous solutions of halogens to test-tubes containing solutions of halide ions. The resulting mixtures are then shaken with cyclohexane, an organic solvent.

One of the student's results is shown in the table.

experiment number	experiment details	colour seen within the organic solvent
1	addition of Cl_2(aq) to I^-(aq) ions	
2	addition of Cl_2(aq) to Br^-(aq) ions	orange
3	addition of Br_2(aq) to Cl^-(aq) ions	

(i) Complete the table to show the expected colours. **[2]**

(ii) Write the ionic equation for the reaction taking place in experiment 2.

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

(iii) These three experiments alone are unable to confirm the order of reactivity for Cl_2, Br_2 and I_2.

Suggest **one** further displacement reaction which could be carried out to confirm the order of reactivity of Cl_2, Br_2 and I_2.

.....

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

(b) Chlorine gas reacts with water as shown below.

$$Cl_2(g) + H_2O(l) \longrightarrow HClO(aq) + HCl(aq)$$

(i) Using oxidation numbers, explain why this reaction is an example of disproportionation.

.....

.....

.....

.....

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

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(ii) State **one** benefit for public health, of the reaction between chlorine gas and water.

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

(c) Group 2 elements and compounds show periodic trends. One trend is shown by the effect of heat upon Group 2 carbonates.

A student carried out an experiment to find out the volume of carbon dioxide obtained by heating a weighed sample of magnesium carbonate.

The student placed a 1.47 g sample of $MgCO_3$ into a test-tube and heated it until there was no further change in mass.

The following reaction took place.

$$MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$$

(i) What type of reaction is this?

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

(ii) What volume of CO_2, in dm^3, would have been given off when measured at room temperature and pressure?

The molar mass of $MgCO_3$ = 84.3 g mol^{-1}

answer = ...dm^3 **[2]**

(iii) The student repeated the experiment a further three times, using the same number of moles of $CaCO_3$, $SrCO_3$ and $BaCO_3$.

What trend in the behaviour of the Group 2 carbonates would be observed by the student?

.....

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

[Total: 12]

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5 This question is about elements in Period 2 of the Periodic Table.

(a) Lithium has a giant metallic structure and a boiling point of 1342 °C.

Describe, with the aid of a labelled diagram, the structure and bonding in lithium and explain why lithium has a high boiling point.

.....

.....

.....

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

(b) Fluorine is a gas at room temperature and has a very low boiling point of –188 °C.

(i) Draw a '*dot-and-cross*' diagram to show the bonding in a fluorine molecule. Show the outer electrons only.

[1]

(ii) Explain why fluorine has a low boiling point.

.....

.....

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

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(c) Fluorine reacts with lithium at room temperature to form a white crystalline solid, lithium fluoride. Lithium fluoride is a good conductor of electricity when molten but not when solid.

(i) Draw a '*dot-and-cross*' diagram to show the bonding in lithium fluoride.
Show the outer electrons only.

[2]

(ii) Explain why lithium fluoride conducts electricity when molten but **not** when solid.

.....

.....

.....

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

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(d) Fluorine reacts with boron, B, to form the fluoride BF_3.

(i) Suggest an equation for this reaction.

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

(ii) Name the shape of, and state the bond angles in, a BF_3 molecule.

Explain why BF_3 has this shape.



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

.....

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

(e) Nitrogen can also form a fluoride, NF_3, which has a permanent dipole.

Explain why NF_3 has a permanent dipole.

.....

.....

.....

.....

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

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(f) Describe and explain the trend in atomic radii of the elements Li to F across Period 2 of the Periodic Table.



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

.....

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.....

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

[Total: 21]

END OF QUESTION PAPER

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ADDITIONAL PAGE

If additional space is required, you should use the lined pages below. The question number(s) must be clearly shown.

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ADDITIONAL PAGE

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ADDITIONAL PAGE

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RECOGNISING ACHIEVEMENT

GCE

Chemistry A

Advanced Subsidiary GCE **F321**

Atoms, Bonds and Groups

Mark Scheme for June 2010

Oxford Cambridge and RSA Examinations

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All Examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

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General advice to Assistant Examiners on the procedures to be used

YOU WILL BE REQUIRED TO UNDERTAKE 10 PRACTICE AND 10 STANDARDISATION SCRIPTS BEFORE STARTING TO MARK LIVE SCRIPTS.

1 The schedule of dates for the marking of this paper is very important. It is vital that you meet these requirements. If you experience problems then you must contact your Team Leader (Supervisor) without delay.

2 An element of professional judgement is required in the marking of any written paper. Candidates often do not use the exact words which appear in the detailed sheets which follow. If the science is correct and also answers the question then the mark(s) should normally be credited. If you are in doubt about the validity of any answer then consult your Team Leader (Supervisor) by phone, the messaging system within SCORIS or e-mail.

3 Correct answers to calculations always gain full credit even if no working is shown. (The 'Show your working' is to help candidates, who may then gain partial credit even if their final answer is not correct.)

4 Some questions may have a 'Level of Response' mark scheme. Any details about these will be in the Additional Guidance.

5 If an answer has been crossed out and no alternative answer has been written then mark the answer crossed out.

6 In addition to the award of 0 marks, there is a NR (No Response) option on SCORIS.

Award 0 marks

- if there is any attempt that earns no credit (including copying out the question or some crossed out working)

Award NR (No Response)

- if there is nothing written at all in the answer space
  OR
- if there is any comment which does not in any way relate to the question being asked (e.g. 'can't do', 'don't know')
  OR
- if there is any sort of mark which is not an attempt at the question (e.g. a dash, a question mark)

7 Abbreviations, annotations and conventions used in the detailed Mark Scheme.

/ = alternative and acceptable answers for the same marking point
not = answers which are not worthy of credit
reject = answers which are not worthy of credit
ignore = statements which are irrelevant
allow = answers that can be accepted
( ) = words which are not essential to gain credit
__ = underlined words must be present in answer to score a mark
ECF = error carried forward
AW = alternative wording
ora = or reverse argument

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8 Annotations: the following annotations are available on SCORIS.

✓	=	correct response
✗	=	incorrect response
bod	=	benefit of the doubt
nbod	=	benefit of the doubt **not** given
ECF	=	error carried forward
^	=	information omitted
I	=	ignore
R	=	reject

9 The Comments box
The comments box will be used by your PE to explain their marking of the practice scripts for your information. Please refer to these comments when checking your practice scripts. You should only type in the comments box yourself when you have an additional object of the type described in Appendix B of the Handbook for Assistant Examiners and Subject Markers.
Please do not use the comments box for any other reason.
Any questions or comments you have for your Team Leader should be communicated by phone, SCORIS messaging system or e-mail.

10 Please send a brief report on the performance of the candidates to your Team Leader (Supervisor) by the end of the marking period. The Assistant Examiner's Report Form (AERF) can be found on the Cambridge Assessment Support Portal. This should contain notes on particular strengths displayed, as well as common errors or weaknesses. Constructive criticisms of the question paper/mark scheme are also appreciated.

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Question			Expected Answers	Marks	Additional Guidance
1	a	i	^{118}Sn 50p 68n 50e Complete row ✓	1	
		ii	$^{120}_{50}$Sn has (two) more neutrons / 70 neutrons ✓ ora	1	**ALLOW** There is a different number of neutrons **IGNORE** correct reference to protons / electrons **DO NOT ALLOW** incorrect references to protons / electrons **ALLOW** ECF for stated number of neutrons from **1a(i)**
	b	i	The (weighted) mean **mass** of an **atom** (of an element) **OR** The (weighted) average **mass** of an **atom** (of an element) ✓ compared with 1/12th (the mass) ✓ of (one atom of) carbon-12 ✓	3	**ALLOW** average atomic mass **DO NOT ALLOW** mean mass of an element **ALLOW** mean mass of isotope**s OR** average mass of isotope**s** **DO NOT ALLOW** the singular; 'isotope' For second **and** third marking points **ALLOW** compared with (the mass of) carbon-12 which is 12 **ALLOW** mass of **one mole** of **atoms** ✓ compared to 1/12th ✓ (mass of) **one mole OR** 12**g** of carbon-12 ✓ **ALLOW** mass of **one mole** of atoms / 1/12th mass of **one mole** OR 12**g** of carbon-12
	c		moles of Sn = $\frac{2080}{118.7}$ = 17.52 ✓ $17.52 \times 6.02 \times 10^{23} = 1.05 \times 10^{25}$ atoms ✓	2	**ALLOW** 17.5 up to (correctly rounded) calculator value of 17.52316765 **DO NOT ALLOW** use of 118, which makes moles of Sn = 17.63 **ALLOW** 105×10^{23} atoms **DO NOT ALLOW** answers which are not to three sig figs for second marking point **ALLOW** two marks for answer only of 1.05×10^{25} **ALLOW** one mark for answer only if not 3 sig figs up to calculator value of $1.054894693 \times 10^{25}$ **Eg 100 × 1** **ALLOW** ECF for **any calculated** moles of Sn (based on use of any A_r value) × 6.02×10^{23} if shown to 3 sig figs **DO NOT ALLOW** mass of Sn × 6.02×10^{23}

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Question			Expected Answers	Marks	Additional Guidance
1	d		$\frac{78.8}{118.7}$ and $\frac{21.2}{16.0}$ **OR** = 0.66(4) and = 1.3(25) ✓ $\frac{0.66(4)}{0.66(4)}$ = 1 $\frac{1.325}{0.66(4)}$ = 2 ans = SnO_2 ✓	2	**ALLOW** SnO_2 for one mark if no working shown **ALLOW** use of 118 for this part **IGNORE** incorrect rounding provided given to two sig figs **IGNORE** incorrect symbols e.g. T or Ti for Tin, as long as correct A_r of tin (118.7 or 118) used **ALLOW** Sn_2O for 1 mark ECF if **both** inverted mole calculations are shown **ALLOW** Sn_3O_5 with **evidence** of use of **both** atomic numbers for one mark **ALLOW** 2 marks if candidate has adopted the following approach 78.8% of mass = 118.7 100% of mass = 118.7/0.788 = 150.6 (151) 150.6 – 118.7 = 31.9 (32) **Both** masses would get one mark 31.9/16 = 2
			Total	**9**	

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Question			Expected Answers	Marks	Additional Guidance
2	a	i	Any **two** from ✓✓ H^+ SO_4^{2-} HSO_4^-	2 max	**DO NOT ALLOW** OH^- **IGNORE** state symbols Charge is essential **ALLOW** H_3O^+ for H^+ and SO_4^{-2} for SO_4^{2-} One answer incorrect = 1 mark max Two answers incorrect = 0 marks
		ii	Effervescence **OR** fizzing **OR** bubbling **OR** gas produced ✓ K_2CO_3 dissolves **OR** disappears **OR** colourless solution is formed ✓ $H_2SO_4 + K_2CO_3 \rightarrow K_2SO_4 + CO_2 + H_2O$ ✓	3	**DO NOT ALLOW** 'carbon dioxide produced' without 'gas' **DO NOT ALLOW** incorrectly named gas produced **DO NOT ALLOW** 'precipitate forms' = CON **ALLOW** 'it' for K_2CO_3 **DO NOT ALLOW** mark for 'dissolves' from state symbols in equation **DO NOT ALLOW** 'potassium' **IGNORE** state symbols **ALLOW** ionic equation
	b	i	$\frac{24.6}{1000} \times 0.100 = 0.00246$ mol ✓ (2.46×10^{-3} mol)	1	**DO NOT ALLOW** 0.0025 as this would lead to 100% in part **(iii)** **DO NOT ALLOW** 0.0024 due to incorrect rounding
		ii	$0.00246 \times 2 = 0.00492$ mol ✓ (4.92×10^{-3} mol)	1	**ALLOW** ECF for ans **(i)** × 2
		iii	Moles of NaOH in 250 cm^3 = $0.00492 \times \frac{250}{25} = 0.0492$ mol ✓ Mass of NaOH in original sample $= 0.0492 \times 40.0 = 1.968$ g ✓ % purity $\frac{1.968}{2.00} \times 100 = 98.4\%$ ✓	3	**ALLOW** ECF for ans **(ii)** × 10 **ALLOW** 1.97g **ALLOW** ECF for moles of NaOH × 40 **ALLOW** 98.5% (from use of 1.97) **ALLOW** ECF for $\frac{\text{mass of NaOH}}{2.00} \times 100$ **DO NOT ALLOW** ECF for 3rd marking point if answer >100% **ALLOW** ECF for 3rd marking point if answer = 100% **ALLOW** molar approach for second and third marks i.e. mol of (expected) NaOH in 2.00 g = 2/40 = 0.05(00) mol (0.0492/0.0500) × 100 = 98.4% 1.6% (the percentage of the impurity present) is likely to be 2 marks, but please check 9.84% has not multiplied up by 10 for first marking point is likely to be 2 marks, but please check
			Total	**10**	

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Question			Expected Answers	Marks	Additional Guidance
3	a		3d 4p ✓	1	Correct order is essential **ALLOW** '3D'
	b	i	A region (within an atom) that can hold (up to) two electrons ✓ (with opposite spin)	1	**ALLOW** 'can be found' for 'can hold' **ALLOW** 'area' **OR** 'volume' **OR** 'space' for region **DO NOT ALLOW** 'place' for region **DO NOT ALLOW** path of an electron **IGNORE** references to 'orbitals being parts of sub-shells'
		ii	11 ✓	1	
	c		18 ✓	1	
	d	i	2nd, 3rd **OR** 1817, 2745 ✓ 10th, 11th **OR** 38458, 42655 ✓	2	Mark as pairs **IGNORE** references to 12th and 13th Three answers with one correct pair = 1 mark Four answers with one correct pair = 1 mark Five answers with both pairs correct = 1 mark Five answers with only one pair correct = 0 marks Six (or more) answers = 0 marks
		ii	$Al^{2+}(g) \rightarrow Al^{3+}(g) + e^{-}$ ✓✓	2	**ALLOW** $Al^{2+}(g) - e^{-} \rightarrow Al^{3+}(g)$ for 2 marks **ALLOW** 1 mark for $Al(g) \rightarrow Al^{3+}(g) + 3e^{-}$ as states are correct **ALLOW** 1 mark for $Al^{2+}(g) + 2e^{-} \rightarrow Al^{3+}(g) + 3e^{-}$ as states are correct **ALLOW** 1 mark if symbol of Al is incorrect, but equation is otherwise fully correct. **ALLOW** e for electron (i.e. no charge) **IGNORE** states on electron
			Total	**8**	

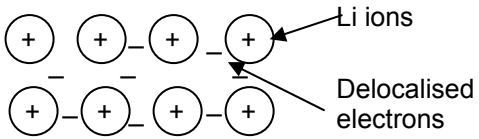
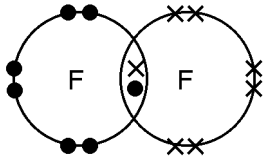
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Question			Expected Answers	Marks	Additional Guidance
4	a	i	1 = purple / lilac / violet / pink / mauve ✓ 3 = orange ✓	2	**ALLOW** any combination of these but no others for 1 **ALLOW** yellow as an alternative for 3 **DO NOT ALLOW** 'precipitate' in either
		ii	$Cl_2 + 2Br^- \longrightarrow 2Cl^- + Br_2$ ✓	1	**IGNORE** state symbols **ALLOW** correct multiples, including fractions
		iii	Addition of $Br_2(aq)$ to $I^-(aq)$ ions ✓	1	**ALLOW** Addition of bromine to iodide (i.e. aqueous not needed) **DO NOT ALLOW** Addition of bromine to iodine **ALLOW** Addition of I_2 to Br^-, but NOT if accompanied by description of displacement of bromine **ALLOW** $Br_2 + I^-$ even if seen in an unbalanced equation
	b	i	Cl_2 is 0 **AND** HCl is –1 **AND** HClO is (+)1 ✓ Chlorine has been both oxidised and reduced **OR** Chlorine's oxidation state has increased and decreased ✓ Chlorine has been oxidised (from 0) to +1 **AND** chlorine has been reduced (from 0) to –1 ✓ (These two points together subsume the second marking point)	3	**ALLOW** 1– **ALLOW** 1+ Oxidation states may be seen above the equation **DO NOT ALLOW** Cl^- in HCl **DO NOT ALLOW** Cl^+ in HClO in text of answer **DO NOT ALLOW** chlor**IDE** in place of 'chlorine' **IF CORRECT OXIDATION STATES ARE SEEN, ALLOW** second **and** third marking points for: Chlorine is oxidised to form HClO Chlorine is reduced to form HCl **ALLOW** Cl or Cl_2 for 'chlorine' **IGNORE** reference to electron loss / gain if correct **DO NOT ALLOW** 3rd mark for reference to electron loss / gain if incorrect **ALLOW** one mark for 'disproportionation is when a species is both oxidised and reduced' if chlorine / chloride is not mentioned
		ii	Kills bacteria **OR** 'kills germs' kills micro-organisms **OR** makes water safe to drink **OR** sterilises water ✓ **OR** 'disinfects'	1	**ALLOW** to make water potable **ALLOW** 'removes' for 'kills' **IGNORE** 'virus' **IGNORE** 'purifies water'
	c	i	**Thermal** decomposition ✓	1	**DO NOT ALLOW** just 'decomposition' or 'thermodecomposition'
		ii	$\frac{1.47}{84.3}$ = 0.0174 mol of $MgCO_3$ ✓ $0.0174 \times 24.0 = 0.418\ dm^3$ **OR** (Calculator value $\times$ 24.0) = 0.419 dm^3 ✓	2	**ALLOW** mol of $MgCO_3$ as calculator value of 0.017437722 or correct rounding to 2 sig figs or more **DO NOT ALLOW** 0.0175 (this has taken M_r of $MgCO_3$ as 84) **ALLOW**, for 2nd mark **calculated moles of $MgCO_3$** $\times$ 24(.0) as calculator value or correct rounding to 2 sig figs or more [e.g. 0.017 $\times$ 24(.0) = 0.408] **DO NOT ALLOW** 84.3 or 1.47 $\times$ 24(.0) as no mole calculation has been done **ALLOW** two marks for correct answer with no working shown

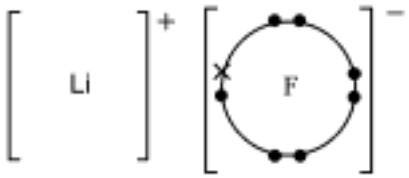
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Question			Expected Answers	Marks	Additional Guidance
4	c	iii	The ease of (thermal) decomposition decreases (down the group) ora ✓	1	**ALLOW** (thermal) stability increases **IGNORE** more heat would be needed **IGNORE** 'takes longer' or 'is slower' **IGNORE** reference to trend in reactivity **IGNORE** answers which include 'more / less mol of CO_2'
			Total	**15**	

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Question			Expected Answers	Marks	Additional Guidance
5	a		 Diagram showing a regular arrangement of **labelled** '**Li^+**' or **'+ ions'** with some attempt to show electrons ✓ Scattering of **labelled** electrons **between** other species **OR** a statement anywhere of **delocalised** electrons (can be in text or in diagram) ✓ The attraction between + ions and e^- is strong **OR** metallic bonding is strong ✓	3	Lattice diagram must have at least two rows of correctly charged ions and a minimum of 2 ions per row **ALLOW** as label: + ions, positive ions, cations If '+' is unlabelled in diagram, award label from a correct statement within the text below **DO NOT ALLOW** 2+, 3+ etc ions **DO NOT ALLOW** for label or in text: nuclei **OR** positive atom **OR** protons **ALLOW** e^- **OR** e as label for electron **ALLOW** a lot of energy is needed to break the (metallic) bond **DO NOT ALLOW** incorrect particles or incorrect attraction e.g. 'intermolecular attraction' or 'nuclear attraction'
	b	i	 Dot and cross bond + 6 matching electrons on each F atom ✓	1	**ALLOW** diagram consisting of all dots **OR** all crosses Circles not essential **ALLOW** 'Fl' for fluorine
		ii	F_2 has induced dipoles **OR** temporary dipoles **OR** van der Waals' forces (between the molecules) ✓ which are **weak** ✓	2	**ALLOW** little energy needed to overcome intermolecular bonding for **second mark** **ALLOW** 'weak' intermolecular bonding for **second mark** **ALLOW** max 1 mark if structure is referred to as giant with first and second marking points correct Award no marks if 'weak' is applied to incorrect bonding. E.g. ionic, covalent, metallic or unspecified bonding

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Question			Expected Answers	Marks	Additional Guidance
5	c	i	 Li shown with either 2 or 0 electrons **and** F shown with 8 electrons with 7 crosses and one dot (or *vice versa*) ✓ correct charges on both ions ✓	2	**For first mark**, if 2 electrons are shown in the cation then the 'extra' electron in the anion must match symbol chosen for electrons in the cation **IGNORE** inner shell electrons **ALLOW** 'Fl' for fluorine Circles not essential **DO NOT ALLOW** Li^+ with 8 electrons Second mark is independent
		ii	Ions cannot move in a solid ✓ **Ions** can move **OR** are mobile when molten ✓	2	**ALLOW** ions are fixed in place **IGNORE** electrons **IGNORE** 'charge carriers' or 'charged particles' **DO NOT ALLOW** ions can move when in solution **IGNORE** charge carriers **IGNORE** 'delocalised ions' or 'free ions' **ALLOW** '**Ions** can only move when molten' for one mark Any mention of electrons moving when molten is a **CON**
	d	i	$2B + 3F_2 \longrightarrow 2BF_3$ ✓	1	**ALLOW** B_2 **ALLOW** multiples including fractions
		ii	*Shape*: trigonal planar ✓ *Bond angle:* 120° ✓ *Explanation*: **Pairs** of electrons repel (one another equally) ✓ **Boron** has 3 bonded pairs (and 0 lone pairs) ✓	4	**'Trigonal planar' must be seen and spelt correctly at least ONCE** **DO NOT ALLOW** 'atoms repel' or 'electrons repel' **ALLOW** 'bonds repel' **ALLOW** diagram showing B atom with three dot-and-cross pairs of electrons, but **no** lone pairs for 4th mark Must refer to boron / central atom **ALLOW** 'bonds' for 'bonded pairs'

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Question			Expected Answers	Marks	Additional Guidance
5	e		F is more electronegative than N **OR** $^{\delta-}$F–N$^{\delta+}$ ✓ Dipoles do not cancel **OR** NF_3 is pyramidal (in words) / asymmetrical ✓	2	**ALLOW** F attracts electrons more than N **ALLOW** N has a partial positive charge **and** F has a partial negative charge (partial must be seen) **DO NOT ALLOW** diagrams that contradict statements about polarity **ALLOW** unsymmetrical, non-symmetrical etc
	f		(As you go across the period) The atomic radii decreases ✓ The nuclear charge increases **OR** protons increase ✓ electrons are added to the same shell **OR** shielding remains the same ✓ great**er** (nuclear) attraction on (outer) electrons / (outer) shell(s) ✓	4	**Use annotations with ticks, crosses ECF etc. for this part** Assume 'across the period from Li to F' **ALLOW** (outer shell) electrons get closer (to nucleus) **IGNORE** 'atomic number increases', but **ALLOW** 'proton number' increases **IGNORE** 'nucleus gets bigger' 'Charge increases' is insufficient **ALLOW** 'effective nuclear charge increases' **OR** 'shielded nuclear charge increases' **Nuclear OR proton(s) OR nucleus spelt correctly ONCE and used in context of 2nd marking point** **ALLOW** shielding is similar **ALLOW** screening for shielding **DO NOT ALLOW** 'subshells' **DO NOT ALLOW** 'distance is similar' This will CON first marking point **ALLOW** 'greater (nuclear) pull for greater nuclear attraction' **DO NOT ALLOW** 'pulled in more' as this is a restatement of the first marking point
			Total	**21**	

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THIS IS A NEW SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE
CHEMISTRY A
Atoms, Bonds and Groups

F321

Candidates answer on the Question Paper

OCR Supplied Materials:
- *Data Sheet for Chemistry A* (inserted)

Other Materials Required:
- Scientific calculator

Thursday 14 January 2010
Morning

Duration: 1 hour

OCE/23953

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

MODIFIED LANGUAGE

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided, however additional paper may be used if necessary.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry A* 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**.
- This document consists of **12** pages. Any blank pages are indicated.

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Answer **all** the questions.

1 Europium, atomic number 63, is used in some television screens to highlight colours. A chemist analysed a sample of europium using mass spectrometry. The results are shown in **Table 1.1** below.

isotope	relative isotopic mass	abundance (%)
^{151}Eu	151.0	47.77
^{153}Eu	153.0	52.23

Table 1.1

(a) Define the term *relative isotopic mass*.

.....

.....

.....

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

(b) Using **Table 1.1**, calculate the relative atomic mass of the europium sample.
Give your answer to **two** decimal places.

answer = ... **[2]**

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(c) Isotopes of europium have differences and similarities.

(i) How is an atom of ^{151}Eu **different** from an atom of ^{153}Eu in terms of protons, neutrons and electrons?

.....

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

(ii) How is an atom of ^{151}Eu **similar** to an atom of ^{153}Eu in terms of protons, neutrons and electrons?

.....

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

(d) Modern plasma television screens emit light when mixtures of noble gases, such as neon and xenon, are ionised.

The first ionisation energies of neon and xenon are shown in the table below.

element	1st ionisation energy / kJ mol^{-1}
neon	+2081
xenon	+1170

Explain why xenon has a lower first ionisation energy than neon.

.....

.....

.....

.....

.....

.....

.....

.....

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

[Total: 9]

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2 A student carries out experiments using acids, bases and salts.

(a) Calcium nitrate, $Ca(NO_3)_2$, is an example of a salt.

The student prepares a solution of calcium nitrate by reacting dilute nitric acid, HNO_3, with the base calcium hydroxide, $Ca(OH)_2$.

(i) Why is calcium nitrate an example of a salt?

.....

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

(ii) Write the equation for the reaction between dilute nitric acid and calcium hydroxide. Include state symbols.

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

(iii) Explain how the hydroxide ion in aqueous calcium hydroxide acts as a base when it neutralises dilute nitric acid.

.....

.....

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

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(b) A student carries out a titration to find the concentration of some sulfuric acid.

The student finds that 25.00 cm^3 of 0.0880 mol dm^{-3} aqueous sodium hydroxide, NaOH, is neutralised by 17.60 cm^3 of dilute sulfuric acid, H_2SO_4.

$$H_2SO_4(aq) + 2NaOH(aq) \longrightarrow Na_2SO_4(aq) + 2H_2O(l)$$

(i) Calculate the amount, in moles, of NaOH used.

answer = ... mol **[1]**

(ii) Determine the amount, in moles, of H_2SO_4 used.

answer = ... mol **[1]**

(iii) Calculate the concentration, in mol dm^{-3}, of the sulfuric acid.

answer = ... mol dm^{-3} **[1]**

(c) After carrying out the titration in **(b)**, the student left the resulting solution to crystallise. White crystals were formed, with a formula of $Na_2SO_4 \bullet \boldsymbol{x} H_2O$ and a molar mass of 322.1 g mol^{-1}.

(i) What term is given to the '$\bullet \boldsymbol{x} H_2O$' part of the formula?

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

(ii) Calculate the value of ***x*** using the molar mass of the crystals.

answer = ... **[2]**

[Total: 10]

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3 This question is about different models of bonding and molecular shapes.

(a) Magnesium sulfide shows ionic bonding.

(i) What is meant by the term *ionic bonding*?

.....

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

(ii) Draw a '*dot-and-cross*' diagram to show the bonding in magnesium sulfide.
Show outer electron shells only.

[2]

(b) '*Dot-and-cross*' diagrams can be used to predict the shape of covalent molecules.

Fluorine has a covalent oxide called difluorine oxide, F_2O. The oxygen atom is covalently bonded to each fluorine atom.

(i) Draw a '*dot-and-cross*' diagram of a molecule of F_2O.
Show outer electron shells only.

[2]

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(ii) Predict the bond angle in an F_2O molecule. Explain your answer.

.....

.....

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.....

.....

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

(c) Liquid ammonia, NH_3, and water, H_2O, both show hydrogen bonding.

(i) Draw a labelled diagram to show hydrogen bonding between two molecules of liquid **ammonia**.

[3]

(ii) Water has several anomalous properties as a result of its hydrogen bonding.

Describe and explain **one** anomalous property of water which results from hydrogen bonding.

.....

.....

.....

.....

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

[Total: 13]

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4 Chlorine and bromine are elements in Group 7 of the Periodic Table.

(a) Chlorine is used in water treatment.

State **one** advantage and **one** disadvantage of using chlorine in water treatment.

advantage: .....

.....

disadvantage: .....

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

(b) The electron configuration of bromine contains outermost electrons in the 4th shell.

Using your knowledge of Group 7 elements, complete the electron configuration of bromine.

$1s^2 2s^2 2p^6 3s^2 3p^6$ ..... **[1]**

(c) Displacement reactions can be used to detect bromide ions in solution.

A student has a solution that contains bromide ions. The student carries out the following experiment.

Step 1

- She bubbles some chlorine gas through a sample of the solution.
- The mixture changes colour.

Step 2

- The student then adds an organic solvent, cyclohexane, to the mixture.
- She shakes the contents and allows the layers to separate.

(i) Write the **ionic** equation for the reaction that takes place in **step 1**.

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

(ii) What colour does the cyclohexane layer turn in **step 2**?

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

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(d) Chlorine reacts differently with dilute and concentrated aqueous solutions of sodium hydroxide.

- When chlorine reacts with dilute sodium hydroxide, one of the products is sodium chlorate(I). This is the reaction that is used to manufacture bleach.
- A different reaction takes place when chlorine is reacted with hot concentrated sodium hydroxide. One of the products is $NaClO_3$, used as a weedkiller.

Chlorine has been both oxidised and reduced in each reaction.

(i) What term is used to describe a redox reaction in which an element is both oxidised and reduced?

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

(ii) Write equations for these two reactions of chlorine with sodium hydroxide:

equation for reaction with **dilute** sodium hydroxide,

.....

equation for reaction with **hot concentrated** sodium hydroxide.

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

(iii) Chlorine forms another chlorate called sodium chlorate(VII), used in the manufacture of matches.

Suggest the formula of sodium chlorate(VII).

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

[Total: 10]

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5 Chemists use the Periodic Table to predict the behaviour of elements.

(a) Early attempts at developing a Periodic Table arranged elements in order of increasing atomic mass.

(i) State which two elements from the **first twenty** elements of the modern Periodic Table are not arranged in order of increasing atomic mass.

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

(ii) Why does the modern Periodic Table **not** arrange some elements, such as those in **a(i)**, in order of increasing atomic mass?

.....

.....

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

(b) Magnesium and strontium are in Group 2 of the Periodic Table.

(i) Magnesium reacts with oxygen to form a white powder called magnesium oxide.

Write the equation for the reaction of magnesium with oxygen.

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

(ii) Magnesium reacts with dilute acids.

Describe what you would expect to see when magnesium ribbon is added to an excess of dilute hydrochloric acid.

.....

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

(iii) Strontium reacts in a similar way to magnesium.

Describe **one** difference you might observe if strontium, instead of magnesium, was reacted with dilute hydrochloric acid.

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

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(c) The third period of the Periodic Table features the elements magnesium and chlorine. The table below shows the melting points of these elements.

element	melting point / °C
magnesium	650
chlorine	–101

Describe the structure and bonding shown by these elements. Use your answer to explain the difference in melting points.



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

.....

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

TURN OVER FOR PART (d)

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(d) The element strontium forms a nitrate, $Sr(NO_3)_2$, which decomposes on heating as shown below.

$$2Sr(NO_3)_2(s) \rightarrow 2SrO(s) + 4NO_2(g) + O_2(g)$$

(i) Using oxidation numbers, explain why the reaction involves both oxidation and reduction.

.....

.....

.....

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

(ii) A student heats 5.29 g of $Sr(NO_3)_2$ and collects the gas at room temperature and pressure, RTP.

$$2Sr(NO_3)_2(s) \rightarrow 2SrO(s) + 4NO_2(g) + O_2(g)$$

Calculate the volume of gas, in dm^3, obtained by the student at RTP.

Molar mass of $Sr(NO_3)_2 = 211.6\,g\,mol^{-1}$.

answer = ... dm^3 **[3]**

[Total: 18]

END OF QUESTION PAPER

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F321 Atoms, Bonds and Groups

Question			Expected Answers	Marks	Additional Guidance
1	(a)		**Mass** of the **isotope** compared to 1/12th **OR** **mass** of the **atom** compared to 1/12th ✓ (the mass of a) carbon-12 **OR** ^{12}C (atom) ✓	2	**IGNORE** Reference to average **OR** weighted mean (i.e. correct definition of relative atomic mass will score both marks) **ALLOW** mass of a **mole** of the isotope/atom with 1/12th the mass of a **mole OR** 12 **g** of carbon-12 for two marks. **ALLOW 2 marks for:** '**Mass** of the isotope **OR mass** of the atom compared to ^{12}C atom given a mass of 12.0' i.e. 'given a mass of 12' **OR** C12 is 12 communicates the same idea as 1/12th.' **ALLOW** 12C **OR** C12 **ALLOW 2 marks for:** $\frac{\text{mass of the isotope}}{\text{mass of 1/12th mass of carbon-12}}$ i.e. fraction is equivalent to 'compared to' **ALLOW 1 mark for** a mix of mass of atom and mass of mole of atoms, i.e. 'mass of the isotope/mass of an atom compared with 1/12th the mass of a **mole OR** 12 g of carbon-12.' **DO NOT ALLOW** mass of 'ions' OR mass of element
	(b)		$\frac{(151 \times 47.77) + (153 \times 52.23)}{100}$ **OR** 72.1327 + 79.9119 **OR** 152.0446 (calculator value) ✓ A_r = 152.04 ✓	2	**ALLOW** Correct answer for two marks **ALLOW** One mark for ECF from transcription error in first sum provided final answer is to 2 decimal points and is to between 151 and 153 and is a correct calculation of the transcription

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Question			Expected Answers	Marks	Additional Guidance
	(c)	(i)	^{153}Eu has (2) more neutrons **OR** ^{153}Eu has 90 neutrons **AND** ^{151}Eu has 88 neutrons ✓	1	**ALLOW** There are a different number of neutrons **IGNORE** Correct references to protons / electrons **DO NOT ALLOW** Incorrect references to protons / electrons
		(ii)	(It has the) same number of protons **AND** electrons **OR** Both have 63 protons and 63 electrons ✓	1	**ALLOW** Same number of protons **AND** same electron configuration **DO NOT ALLOW** 'Same number of protons' without reference to electrons (and vice versa)

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Question			Expected Answers	Marks	Additional Guidance
	(d)		Xe has a bigger atomic radius **OR** Xe has more shells ✓	3	**ALLOW** Xe has more energy levels **ALLOW** Xe has electrons in higher energy level **ALLOW** Xe has electrons further from nucleus **IGNORE** Xe has more orbitals **OR** more sub-shells **DO NOT ALLOW** 'different shell' or 'new shell'
			Xe has **more** shielding ✓		**ALLOW More** screening There must be a clear comparison ie **more** shielding **OR** **increased** shielding. i.e. **DO NOT ALLOW** Xe 'has shielding' **ALLOW** Xe has **more** electron repulsion from inner shells
			The nuclear attraction decreases **OR** Outermost electrons of Xe experience less attraction (to nucleus) **OR** Increased shielding / distance outweighs the increased nuclear charge ✓ ORA throughout		**ALLOW** Xe has less nuclear pull **IGNORE** Xe has less effective nuclear charge **DO NOT ALLOW** nuclear charge for nuclear attraction
			Total	**9**	

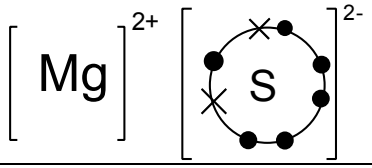
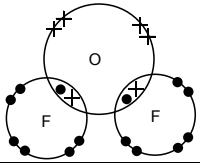
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Question			Expected Answers	Marks	Additional Guidance
2	(a)	(i)	The H^+ ion in an (nitric) acid has been replaced by a metal ion **OR** by a Ca^{2+} ion ✓	1	**DO NOT ALLOW** it has been produced by the reaction of an acid and a base as this is stated in the question. **IGNORE** references to replacement by NH_4^+ ions or positive ions. **ALLOW** H **OR** Hydrogen for H^+; **DO NOT ALLOW** Hydrogen atoms **ALLOW** Ca **OR** Calcium for Ca^{2+}. **DO NOT ALLOW** Calcium atoms **ALLOW** 'metal' for 'metal ion
		(ii)	$2HNO_3(aq) + Ca(OH)_2(aq) \rightarrow Ca(NO_3)_2(aq) + 2H_2O(l)$ Formulae ✓ Balance **AND** states ✓	2	**ALLOW** multiples **ALLOW** (aq) **OR** (s) for $Ca(OH)_2$
		(iii)	Accepts a **proton OR** accepts H^+ ✓	1	**ALLOW** $H^+ + OH^- \rightarrow H_2O$ **ALLOW** OH^- reacts with H^+ **OR** OH^- takes H^+ **ALLOW** OH^- 'attracts' H^+ if 'to form water' is seen **DO NOT ALLOW** OH^- neutralises H^+ ('neutralises' is in the question)
	(b)	(i)	Calculates correctly $\frac{0.0880 \times 25.0}{1000} = 2.20 \times 10^{-3}$ mol **OR** 0.00220 mol ✓	1	**ALLOW** 0.0022 **OR** 2.2×10^{-3} mol
		(ii)	Calculates correctly $\frac{0.00220}{2} = 1.10 \times 10^{-3}$ mol **OR** 0.00110 mol ✓	1	**ALLOW** 0.0011 **OR** 1.1×10^{-3} mol **ALLOW** ECF for answer **(i)**/2 as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes
		(iii)	$\frac{0.00110 \times 1000}{17.60} = 0.0625$ mol dm^{-3} **OR** 6.25×10^{-2} mol dm^{-3} ✓	1	**ALLOW** 0.063 **OR** 6.3×10^{-2} mol dm^{-3} **ALLOW** ECF for answer **(ii)** × 1000/17.60 **OR** ECF from **(i)** for answer **(i)**/2 × 1000/17.60 as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes

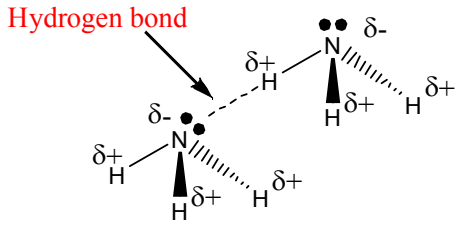
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	(c)	**(i)**	(The number of) Water(s) of crystallisation ✓	**1**	**IGNORE** hydrated **OR** hydrous
		(ii)	142.1 ✓ $x = \frac{322.1 - 142.1}{18.0} = 10$ ✓	**2**	**ALLOW** 142 **ALLOW** M_r expressed as a sum **ALLOW** ECF from incorrect M_r and x is **calculated correctly** **ALLOW** ECF values of x from nearest whole number to calculator value **ALLOW** 2 marks if final answer is 10 **without any working**
			Total	**10**	

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Question			Expected Answers	Marks	Additional Guidance
3	(a)	(i)	(Electrostatic) **attraction** between oppositely charged **ions**. ✓	1	**IGNORE** force **IGNORE** references to transfer of electrons **MUST** be ions, not particles
		(ii)	Mg shown with either 8 of 0 electrons **AND** S shown with 8 electrons **with** 2 crosses and 6 dots (or vice versa) ✓ Correct charges on both ions ✓ 	2	Mark charges on ions and electrons independently **For first mark**, if 8 electrons are shown around the Mg then 'extra electrons' around S must match the symbol chosen for electrons around Mg Shell circles not required **IGNORE** inner shell electrons Brackets are not required
	(b)	(i)	Electron pairs in covalent bonds shown correctly using dots and crosses in a molecule of the F_2O ✓ Lone pairs correct on O and both F atoms ✓ 	2	Must be '*dot-and-cross*' circles for outer shells **NOT** needed **IGNORE** inner shells Non-bonding electrons of O do not need to be shown as pairs Non-bonding electrons of F do not need to be shown as pairs
		(ii)	Predicted bond angle 104–105°. ✓ There are 2 bonded pairs and 2 lone pairs ✓ Lone pairs repel more than bonded pairs ✓	3	**ALLOW** 103–105° (103° is the actual bond angle) **ALLOW** responses equivalent to second marking point. e.g. There are 4 pairs of electrons and 2 of these are lone pairs **ALLOW** 'bonds' for 'bonded pairs' **DO NOT ALLOW** 'atoms repel' **DO NOT ALLOW** electrons repel **ALLOW** LP for 'lone pair' **ALLOW** BP for bonded pair **ALLOW** LP repel more if bonded pairs have already been mentioned

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Question			Expected Answers	Marks	Additional Guidance
	(c)	(i)	(At least) two **NH_3** molecules with correct dipole shown with at least one H with δ^+ and one N with δ^- ✓	3	**DO NOT ALLOW** first mark for ammonia molecules with incorrect lone pairs **DO NOT ALLOW** first mark if H_2O, NH_2 or NH is shown
			(Only) one hydrogen bond from N atom on one molecule to a H atom on another molecule ✓		**ALLOW** hydrogen bond need not be labelled as long as it clear the bond type is different from the covalent N–H bond **ALLOW** a line (i.e. looks like a covalent bond) as long as it is labelled 'hydrogen bond)
			Lone pair shown on the N atom and hydrogen bond must hit the lone pair ✓  		**ALLOW** 2-D diagrams **ALLOW** two marks if water molecules are used. One awarded for a correct hydrogen bond and one for the involvement of lone pair
		(ii)	Liquid H_2O is denser than solid ✓ In solid state H_2O molecules are held apart by hydrogen bonds **OR** ice has an open lattice ✓ **OR** H_2O has a relatively high boiling point **OR** melting point ✓ (relatively strong) hydrogen bonds need to be broken **OR** a lot of energy is needed to overcome hydrogen bonds **OR** hydrogen bonds are strong ✓	2	ORA **ALLOW** ice floats for first mark **ALLOW** higher melting **OR** boiling point than expected **DO NOT ALLOW** H_2O has a high melting / boiling point **ALLOW** other properties caused by hydrogen bonding not mentioned within the specification E.g. high surface tension – strong hydrogen bonds on the surface
			Total	**13**	

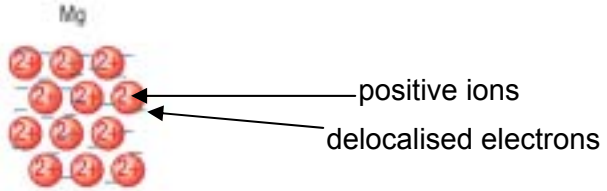
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Question			Expected Answers	Marks	Additional Guidance
4	(a)		*Advantage* removes or kills bacteria **OR** kills germs **OR** kills micro-organisms **OR** make it safe to drink **OR** sterilises water **OR** disinfects water ✓ *Disadvantage* it is toxic **OR** poisonous **OR** could form chlorinated hydrocarbons ✓	**2**	**ALLOW** to make water potable **IGNORE** virus **IGNORE** 'purifies water' **DO NOT ALLOW** 'antiseptic' **ALLOW forms** carcinogens **OR** forms toxins **IGNORE** harmful **DO NOT ALLOW** 'it causes cancer' **DO NOT ALLOW** "It kills you"
	(b)		$3d^{10}\ 4s^2\ 4p^5$ ✓	**1**	**ALLOW** $4s^2\ 3d^{10}\ 4p^5$ **ALLOW** subscripts or $3D^{10}$ **ALLOW** answers with $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$ appearing twice
	(c)	**(i)**	$Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$ ✓	**1**	**IGNORE** state symbols **ALLOW** any correct multiple including fractions
		(ii)	Yellow / orange / red / brown ✓	**1**	**ALLOW** any combination of these, but no others
	(d)	**(i)**	Disproportionation ✓	**1**	**ALLOW** versions which sound the same **DO NOT ALLOW** disproportional **OR** disproportionate **OR** disproportion
		(ii)	$Cl_2 + 2NaOH \rightarrow NaClO + NaCl + H_2O$ ✓ $3Cl_2 + 6NaOH \rightarrow NaClO_3 + 5NaCl + 3H_2O$ Cl_2 and NaOH as reactants **AND** $NaClO_3$ and NaCl as products✓ Rest of the equation ✓	**3**	**ALLOW** multiples for either equation **ALLOW** $3Cl_2 + 6NaOH \rightarrow 2NaClO_3 + 4NaCl + 3H_2$
		(iii)	$NaClO_4$ ✓	**1**	**ALLOW** Na_3ClO_5 etc
			Total	**10**	

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Question			Expected Answers	Marks	Additional Guidance
5	(a)	(i)	Potassium **AND** argon ✓	1	**ALLOW** K and Ar
		(ii)	They are arranged in increasing atomic number **OR** Neither would show properties **OR** trends of rest of group **OR** Neither would show properties **OR** trends of rest of period **OR** They are arranged by electron configuration ✓	1	**ALLOW** any correct property difference e.g. This would place a reactive metal in the same group as noble gases **ALLOW** they do not fit in with the rest of the group
	(b)	(i)	$2Mg + O_2 \rightarrow 2MgO$ ✓	1	**ALLOW** multiples. Correct species must be seen **IGNORE** state symbols
		(ii)	Fizzes **OR** bubbles **OR** gas produced **OR** effervescing ✓ Mg dissolves **OR** Mg disappears **OR** a solution is formed ✓	2	**DO NOT ALLOW** 'carbon dioxide gas produced' **DO NOT ALLOW** 'hydrogen produced' without 'gas' **ALLOW** 'it for Mg' **IGNORE** Mg reacts **IGNORE** temperature change **IGNORE** steam produced
		(iii)	Quicker **OR** more vigorous **OR** gets hotter	1	**MUST** be a comparison of a reaction observation, not just 'more reactive' **ALLOW** any comparison of greater rate including more bubbles etc. **DO NOT ALLOW** more gas produced

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Question	Expected Answers	Marks	Additional Guidance
(c)	Mg has a **giant** structure ✓	6	
	Mg has **metallic** bonding OR description of metallic bonding as positive ions and **delocalised** electrons ✓		**Metallic OR delocalised** seen spelt correctly at least **ONCE**
	(There is electrostatic attraction between) positive ions and electrons ✓		**DO NOT ALLOW** as label nuclei **OR** protons for positive ions **ALLOW labelled** diagram of metallic bonding for second and third marks  Lattice must have at least two rows of positive ions. If a Mg ion is shown it must correct charge **ALLOW** for labels:+ ions, positive ions, cations **DO NOT ALLOW** as label nuclei **OR** protons for positive ions **ALLOW** e^- or e as label for electron **DO NOT ALLOW** '–' without label for electron
	Cl has a simple molecular **OR** simple covalent (lattice) ✓		**Covalent OR molecule OR molecular** seen spelt correctly at least **ONCE** **ALLOW** Cl is a (covalent) **molecule**
	Cl has van der Waals' forces (between molecules) **OR** Cl has instantaneous dipole–induced dipoles **OR** temporary dipole–temporary dipole ✓		**IGNORE** Cl has intermolecular bonding

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			van der Waals' forces are weak **and** metallic bonds are strong **OR** van der Waals' forces are weak**er** than metallic bonds **OR** Less energy is needed to overcome van der Waals' than metallic bonds ✓		**ALLOW** ECF from incorrect descriptions of giant structure with strong bonds; e.g. Mg has giant ionic structure **ALLOW** ECF from any incorrect intermolecular forces e.g. permanent dipole –dipole from marking point 5 **ALLOW** vdW easi**er** to break ORA
	(d)	**(i)**	O goes from –2 to 0 ✓ N goes from +5 to +4 ✓ N is reduced **AND** O is oxidised ✓	**3**	Oxidation numbers may be seen with equation Third mark is dependent upon seeing a reduction in oxidation number of N and an increase in oxidation number of O **ALLOW** ECF for third mark for N is oxidised **and** O is reduced if incorrect oxidation numbers support this **IGNORE** references to strontium **IGNORE** references to electron loss **OR** gain **DO NOT ALLOW** 'One increases and one decreases'

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	(d)	(ii)	Calculates correctly: Mol of $Sr(NO_3)_2$ = $\frac{5.29}{211.6}$ = 0.0250 ✓ Calculates correctly: Mol of gas = 5/2 × 0.0250 = 0.0625 ✓ Calculates correctly: Volume of gas = 24.0 × 0.0625 = 1.50 dm^3 ✓	3	**ALLOW** 0.025 **ALLOW** ECF for first answer × 2.5 as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes **ALLOW** ECF for second answer × 24(.0) as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes **DO NOT ALLOW** ECF of first answer × 24(.0) (which gives 0.6(0) dm^3) as this has not measured the volume of any gas, simply 0.0250 mol of solid $Sr(NO_3)_2$ converted into a gas i.e. This answer would give **one** mark **ALLOW** 1.5 dm^3 **ALLOW** ECF producing correct volume of NO_2 only i.e. 1.2(0) dm^3 would give **two** marks **OR** **ALLOW** ECF producing correct volume of O_2 only i.e. 0.3(0) dm^3 would give **two** marks
			Total	**18**	

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THIS IS A NEW SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE
CHEMISTRY A
Atoms, Bonds and Groups

F321

Candidates answer on the question paper

OCR Supplied Materials:
- *Data Sheet for Chemistry A* (Inserted)

Other Materials Required:
- Scientific calculator

Wednesday 3 June 2009
Morning

Duration: 1 hour

CUP/T73723

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided, however additional paper may be used if necessary.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry A* 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**.
- This document consists of **12** pages. Any blank pages are indicated.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	15	
2	12	
3	7	
4	11	
5	15	
TOTAL	60	

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Answer **all** the questions.

1 The Group 2 element magnesium was first isolated by Sir Humphry Davy in 1808.

(a) Magnesium has three stable isotopes, which are ^{24}Mg, ^{25}Mg and ^{26}Mg.

(i) Complete the table below to show the atomic structures of ^{24}Mg and ^{25}Mg.

	protons	**neutrons**	**electrons**
^{24}Mg			
^{25}Mg			

[2]

(ii) A sample of magnesium contained ^{24}Mg: 78.60%; ^{25}Mg: 10.11%; ^{26}Mg: 11.29%.

Calculate the relative atomic mass of this sample of Mg.

Give your answer to **four** significant figures.

answer = ... **[2]**

(iii) Define the term *relative atomic mass*.

.....

.....

.....

.....

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

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(b) The reaction between magnesium and sulfuric acid is a redox reaction.

$$Mg(s) + H_2SO_4(aq) \longrightarrow MgSO_4(aq) + H_2(g)$$

(i) Use oxidation numbers to identify which element has been oxidised.

Explain your answer.

element oxidised .....

explanation .....

.....

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

(ii) Describe what you would **see** when magnesium reacts with an excess of sulfuric acid.

.....

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

(c) Epsom salts can be used as bath salts to help relieve aches and pains.

Epsom salts are crystals of hydrated magnesium sulfate, $MgSO_4 \bullet \boldsymbol{x}H_2O$.

A sample of Epsom salts was heated to remove the water. 1.57 g of water was removed leaving behind 1.51 g of anhydrous $MgSO_4$.

(i) Calculate the amount, in mol, of anhydrous $MgSO_4$ formed.

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

(ii) Calculate the amount, in mol, of H_2O removed.

amount = ... mol **[1]**

(iii) Calculate the value of $\boldsymbol{x}$ in $MgSO_4 \bullet \boldsymbol{x}H_2O$.

$\boldsymbol{x}$ = ... **[1]**

[Total: 15]

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2 This question compares the bonding, structure and properties of sodium and sodium oxide.

(a) Sodium, Na, is a metallic element.

Explain, with the aid of a labelled diagram, what is meant by the term *metallic bonding*.

.....

.....

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

(b) Sodium reacts with oxygen to form sodium oxide, Na_2O, which is an ionic compound.

(i) Write the equation for the reaction of sodium with oxygen to form sodium oxide.

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

(ii) State what is meant by the term *ionic bond*.

.....

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

(iii) Draw a '*dot-and-cross*' diagram to show the bonding in Na_2O.

Show **outer** electrons only.

[2]

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(c) Compare and explain the electrical conductivities of sodium and sodium oxide in the solid and liquid states.

.....

.....

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.....

..... **[5]**

[Total: 12]

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3 Calcium carbonate, $CaCO_3$, reacts with hydrochloric acid as shown in the equation below.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

(a) 7.50×10^{-3} mol $CaCO_3$ reacts with 0.200 mol dm^{-3} HCl.

(i) Calculate the volume, in cm^3, of 0.200 mol dm^{-3} HCl required to react with 7.50×10^{-3} mol $CaCO_3$.

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

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

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

(b) When heated strongly, $CaCO_3$ decomposes.

Write an equation, including state symbols, for the thermal decomposition of $CaCO_3$.

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

(c) Calcium oxide reacts with water and with nitric acid.

State the formula of the calcium compound formed when:

(i) calcium oxide reacts with water, ... **[1]**

(ii) calcium oxide reacts with nitric acid. ..... **[1]**

[Total: 7]

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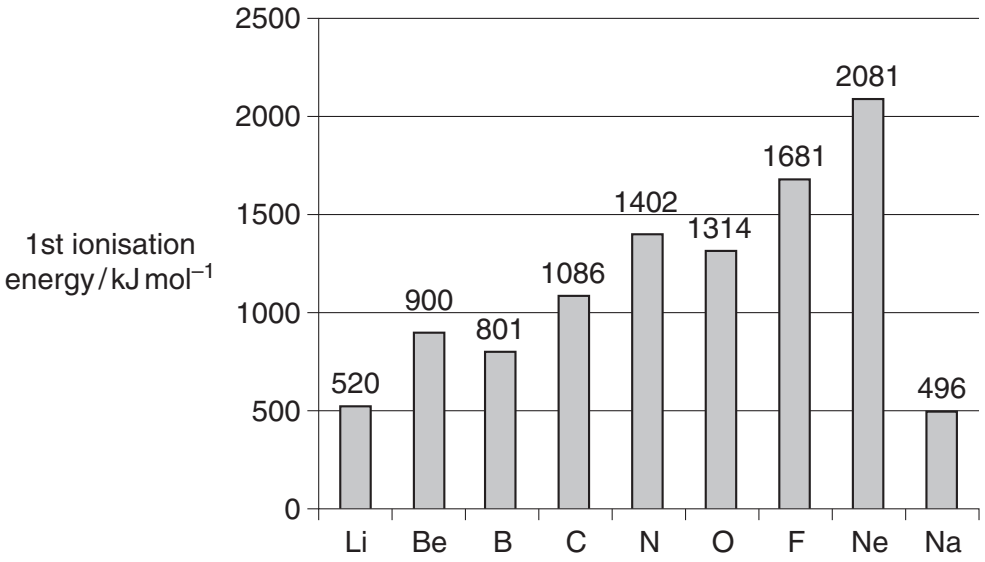
TURN OVER FOR QUESTION 4

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4 Ionisation energies have been used to develop the model of the atom.

The first ionisation energies of the elements Li to Na are shown in the figure below.



(a) Define the term *first ionisation energy*.

.....

.....

.....

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

(b) **(i)** Explain why the first ionisation energies show a general increase from Li to Ne.

.....

.....

.....

.....

.....

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

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(ii) Explain the difference between the first ionisation energies of Li and Na.



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

.....

.....

.....

.....

.....

.....

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

(c) The first ionisation energy of oxygen is 1314 kJ mol^{-1} and the second ionisation energy of oxygen is 3388 kJ mol^{-1}.

(i) Write an equation to represent the **second** ionisation energy of oxygen.

Include state symbols.

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

(ii) Suggest why the second ionisation energy of oxygen has a greater value than the first ionisation energy of oxygen.

.....

.....

.....

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

[Total: 11]

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5 The Periodic Table is a table of elements arranged in order of atomic number. The elements are classified into blocks.

(a) (i) State what is meant by the term *atomic number*.

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

(ii) Complete the full electron configuration for a titanium atom.

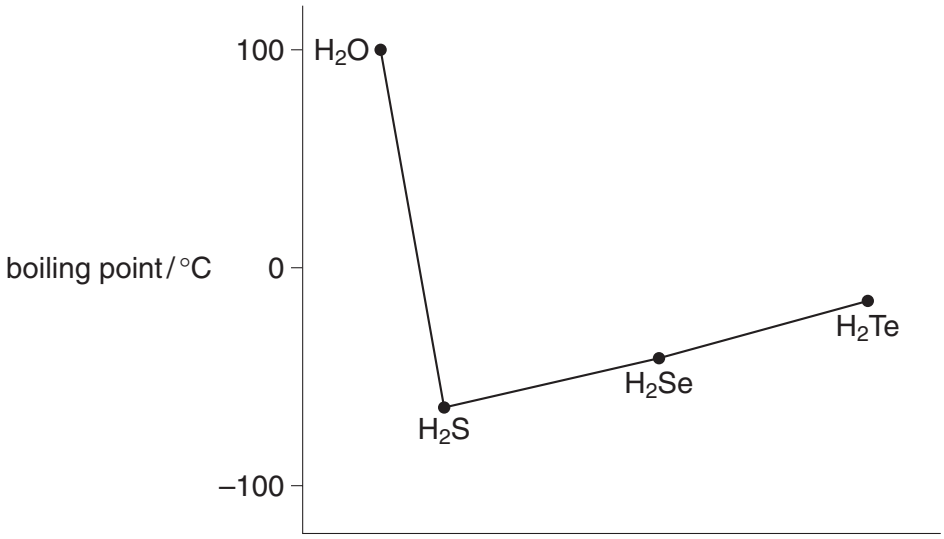
$1s^2$ ..... **[1]**

(iii) Identify the **seventh** element in the **fourth** period.

State which block this element is in.

element ..... block ..... **[1]**

(b) The figure below shows the boiling points of four hydrides of Group 6 elements.



(i) Explain, with the aid of a diagram, the intermolecular forces in H_2O that lead to the relatively high boiling point of H_2O.

.....

.....

.....

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

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(ii) Suggest why H_2S has a much lower boiling point than H_2O.

.....

.....

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

(c) The boiling points of some Group 7 elements are shown below.

Group 7 element	boiling point / °C
chlorine	–35
bromine	59
iodine	184

Explain why the halogens show this trend in boiling points.



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

.....

.....

.....

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.....

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

TURN OVER FOR QUESTION 5(d)

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(d) During the extraction of bromine industrially, chlorine is bubbled through a solution of bromide ions. A student thought this principle would also work for extracting iodine and carried out the experiment below.

Stage 1 The student bubbled some chlorine through an aqueous solution of potassium iodide.

Stage 2 The student added an organic solvent and shook the mixture.

(i) What would the student see at **stage 1**?

.....

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

(ii) Name the products and write an ionic equation for the reaction in **stage 1**.

names of products: .....

ionic equation: ..... **[2]**

(iii) Why does the reaction in **stage 1** occur?

.....

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

(iv) What would the student see at **stage 2**?

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

[Total: 15]

END OF QUESTION PAPER

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F321 Atoms, Bonds and Groups

<table>
<tr><th colspan="3">Question</th><th>Expected Answers</th><th>Marks</th><th>Additional Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td>(i)</td><td>
<table>
<tr><th></th><th>protons</th><th>neutrons</th><th>electrons</th></tr>
<tr><td>^{24}Mg</td><td>12</td><td>12</td><td>12</td></tr>
<tr><td>^{25}Mg</td><td>12</td><td>13</td><td>12</td></tr>
</table>
^{24}Mg line correct ✓
^{25}Mg line correct ✓</td><td>2</td><td>mark by row</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>$\frac{24 \times 78.60 + 25 \times 10.11 + 26 \times 11.29}{100}$

OR 18.8640 + 2.5275 + 2.9354

OR 24.3269 ✓

A_r = 24.33 (to 4 sig figs) ✓</td><td>2</td><td>ALLOW two marks for A_r = 24.33 with no working out

ALLOW one mark for ecf from incorrect sum provided final answer is between 24 and 26 and is to 4 significant figures, e.g. 24.3235 ✖ gives ecf of 24.32 ✓</td></tr>
<tr><td></td><td></td><td>(iii)</td><td>The (weighted) mean mass of an atom
OR (weighted) average mass of an atom ✓

relative to 1/12th (the mass) ✓

of (one atom of) ^{12}C ✓</td><td>3</td><td>ALLOW The (weighted) mean mass
OR (weighted) average mass of an atom
OR average atomic mass ✓
compared with (the mass of) carbon-12 ✓
which is 12 ✓

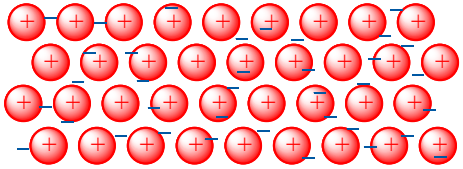
For 1st marking point, ALLOW mean mass of the isotopes
OR average mass of the isotopes
Do NOT ALLOW the singular: isotope

ALLOW mass of one mole of atoms ✓
compared to 1/12th ✓
(the mass) of one mole / 12 g of carbon-12 ✓</td></tr>
</table>

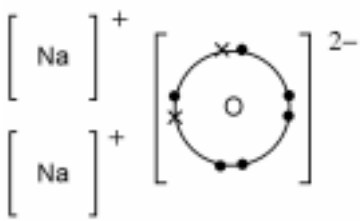
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Question			Expected Answers	Marks	Additional Guidance
					$\frac{\text{mass of one mole of atoms}}{1/12\text{th}}$ ✓ the mass of one mole / 12 g of carbon-12 ✓
	(b)	(i)	Mg ✓ oxidation number changes from 0 to (+)2 **OR** oxidation number increases by 2 ✓	2	**ALLOW** correct oxidation numbers shown in equation 2nd mark is dependent on identification of Mg **IGNORE** electrons
		(ii)	Mg/solid dissolves **OR** Mg/solid disappears **OR** (Mg/solid) forms a solution ✓ bubbles **OR** fizzes **OR** effervesces **OR** gas produced ✓	2	**IGNORE** metal reacts **IGNORE** temperature change **IGNORE** steam produced **DO NOT ALLOW** carbon dioxide gas produced **DO NOT ALLOW** hydrogen produced without **gas**
	(c)	(i)	$M(MgSO_4)$ = 120.4 OR 120 (g mol^{-1}) ✓ mol $MgSO_4 = \frac{1.51}{120.4} = 0.0125\ mol$ ✓	2	**ALLOW** 0.013 up to calculator value of 0.012541528 correctly rounded (from M = 120.4 g mol^{-1}) **ALLOW** 0.013 up to calculator value of 0.012583333 correctly rounded (from M = 120 g mol^{-1}) **ALLOW** ecf from incorrect M i.e. 1.51 ÷ M
		(ii)	$\frac{1.57}{18.0}$ = 0.0872(2) (mol) ✓	1	**ALLOW** 0.09 up to calculator value of 0.08722222
		(iii)	x = 7 ✓	1	**ALLOW** ecf i.e. answer to (ii) ÷ answer to (i) **ALLOW** correctly calculated answer from 1 significant figure up to calculator value, ie, x does not have to be a whole number. Likely response = 6.95 ✓
			Total	15	

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Question			Expected Answers	Marks	Additional Guidance
2	(a)		 regular arrangement of **labelled** + ions with some attempt to show electrons ✓ scattering of labelled electrons **between** other species **OR** a statement anywhere of **delocalised** electrons (can be in text below) ✓ metallic bond as (electrostatic) **attraction** between the electrons and the positive ions ✓	3	Lattice must have at least 2 rows of positive ions If a metal ion is shown (e.g. Na^+), it must have the correct charge **ALLOW** for labels: + ions, positive ions, cations If '+' is unlabelled in diagram, award the label for '+' from a statement of 'positive ions' in text below **DO NOT ALLOW** as label or text positive atom **OR** protons **OR** nuclei **ALLOW** e^- **OR** e as label for electron **DO NOT ALLOW** '–' as label for electron
	(b)	**(i)**	$4\ Na + O_2 \longrightarrow 2\ Na_2O$ **OR** $2\ Na + ½\ O_2 \longrightarrow Na_2O$ ✓	**1**	**ALLOW** correct multiples including fractions **IGNORE** state symbols
		(ii)	(electrostatic) attraction between oppositely charged ions✓	**1**	

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Question			Expected Answers	Marks	Additional Guidance
		(iii)	 Na shown with either 8 or 0 electrons **AND** O shown with 8 electrons **with** 6 crosses and 2 dots (or vice versa) ✓ Correct charges on both ions ✓	**2**	**For 1st mark,** if 8 electrons shown around cation then 'extra' electron(s) around anion must match symbol chosen for electrons in cation Shell circles not required **IGNORE** inner shell electrons **ALLOW:** $2[Na^+]$ $2[Na]^+$ $[Na^+]_2$ (brackets not required) **DO NOT ALLOW** $[Na_2]^{2+}$ / $[Na_2]^+$ / $[2Na]^{2+}$ **DO NOT ALLOW**: $[Na_2]^{2+}$ $[Na_2]^+$ $[2Na]^{2+}$ $[Na]_2^+$
	(c)		sodium is a (good) conductor because it has mobile electrons **OR** delocalised electrons **OR** electrons can move ✓ sodium oxide does not conduct as a solid ✓ sodium oxide conducts when it is a liquid ✓ ions cannot move in a solid ✓ **ions** can move **OR** are mobile when liquid ✓	**5**	**Throughout this question, 'conducts' and 'carries charge' are treated as equivalent terms.** **DO NOT ALLOW** 'free electrons' for mobile electrons **ALLOW** poor conductor **OR** bad conductor 'Sodium oxide only conducts when liquid' is insufficient to award 'solid conductivity' mark **ALLOW** ions are fixed in place **IGNORE** electrons **IGNORE** charge carriers **IGNORE** 'delocalised ions' or 'free ions' for mobile ions Any mention of electrons moving is a **CON**
			Total	**12**	

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Question			Expected Answers	Marks	Additional Guidance
3	(a)	(i)	mol HCl = 1.50×10^{-2} ✓ volume HCl(aq) = 75.0 ✓	2	**ALLOW** answers to 2 significant figures **ALLOW** ecf from wrong number of moles i.e. $\frac{\text{moles of HCl} \times 1000}{0.200}$ **ALLOW** one mark for 37.5 (from incorrect 1:1 ratio)
		(ii)	180 ✓	1	No other acceptable answer
	(b)		$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$ equation ✓ state symbols ✓	2	state symbols are **dependent** on correct formulae of $CaCO_3$, CaO and CO_2 **DO NOT ALLOW** the 'equation mark' if O_2 is seen on both sides (but note that the 'state symbol mark' may still be accessible)
	(c)	(i)	$Ca(OH)_2$ ✓	1	**IGNORE** charges, even if wrong
		(ii)	$Ca(NO_3)_2$ ✓	1	**IGNORE** charges, even if wrong
			Total	7	

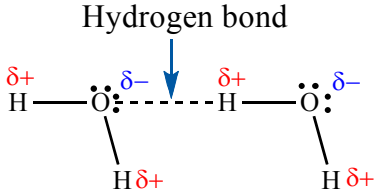
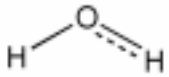
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Question			Expected Answers	Marks	Additional Guidance
4	(a)	(i)	the energy required to remove one electron ✓ from each atom in one mole ✓ of gaseous atoms ✓	3	**ALLOW** 3 marks for: the energy required to remove one mole of electrons ✓ from one mole of atoms ✓ atoms in the gaseous state ✓ If no definition, **ALLOW one** mark for the equation below, including state symbols. $X(g) \rightarrow X^+(g) + e^-$ / $X(g) - e^- \rightarrow X^+(g)$ **ALLOW** e for electron **IGNORE** state symbol for electron
	(b)	(i)	outer electrons closer to nucleus **OR** radii decreases ✓ nuclear charge increases **OR** protons increase ✓ electrons added to the same shell **OR** screening **OR** shielding remains the same ✓	3	 **IGNORE** 'atomic number increases' **IGNORE** 'nucleus gets bigger' 'charge increases' is not sufficient **ALLOW** 'effective nuclear charge increases' **OR** 'shielded nuclear charge increases' **ALLOW** shielding is similar
		(ii)	atomic radii increase **OR** there are more shells ✓ there is **more** shielding **OR more** screening ✓	3	**ALLOW** electrons in higher energy level **ALLOW** electrons are further from the nucleus **DO NOT ALLOW** more orbitals **OR** more sub-shells **DO NOT ALLOW** different shell or new shell There must be a clear comparison: *e.g.* '**more** shielding'**,** '**increased** shielding'. *i.e.* **DO NOT ALLOW** just 'shielding'. **ALLOW** '**more** electron repulsion from inner shells'

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Question			Expected Answers	Marks	Additional Guidance
			the nuclear attraction decreases **OR** Increased shielding / distance outweigh the increased nuclear charge ✓		**Nuclear OR proton(s) OR nucleus spelt correctly ONCE** **ALLOW** 'nuclear pull' **IGNORE** any reference to 'effective nuclear charge'
	(c)	**(i)**	$O^{+}(g) \longrightarrow O^{2+}(g) + e^{-}$ ✓	**1**	answer **must have** state symbols **ALLOW** e for electron **ALLOW** $O^{+}(g) - e^{-} \rightarrow O^{2+}(g)$ **DO NOT ALLOW** $O^{+}(g) + e^{-} \longrightarrow O^{2+}(g) + 2e^{-}$ **IGNORE** state symbol for electron
		(ii)	the O^{+} ion, is smaller than the O atom **OR** the electron repulsion/shielding is smaller **OR** the proton : electron ratio in the 2+ ion is greater than in the 1+ ion ✓	**1**	**ALLOW** the outer electrons in an O^{+} ion are closer to the nucleus than an O atom **DO NOT ALLOW** 'removed from next shell down'
			Total	**11**	

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Question			Expected Answers	Marks	Additional Guidance
5	(a)	(i)	number of protons (in the nucleus) ✓	1	**ALLOW** proton number **ALLOW** number of protons in an atom **IGNORE** reference to electrons
		(ii)	$(1s^2)2s^22p^63s^23p^63d^24s^2$ ✓	1	**ALLOW** $1s^2$ written twice **ALLOW** subscripts **ALLOW** $4s^2$ before $3d^{2+}$
		(iii)	Mn / manganese **and** d ✓	1	**ALLOW** D
	(b)	(i)	 Shape of water with at least one H with δ+ and at least one O with δ– ✓ H-bond between H in one water molecule and a lone pair of an O in another water molecule✓ hydrogen bond labelled **OR** H_2O has hydrogen bonding ✓	3	all marks can be awarded from a labelled diagram If HO_2 shown then **DO NOT ALLOW** 1st mark Dipole could be described in words so it does **not** need to be part of diagram. At least one hydrogen bond **must** clearly hit a lone pair Lone pair interaction could be described in words so it does **not** need to be part of diagram. **DO NOT ALLOW** hydrogen bonding if described in context of intramolecular bonding, *ie* 
		(ii)	no hydrogen bonding **OR** weaker intermolecular forces ✓	1	**DO NOT ALLOW** 'weaker'/ 'weak' hydrogen bonding **ALLOW** weaker van der Waals' forces **ALLOW** weaker dipole-dipole interactions **DO NOT ALLOW** 'weak intermolecular forces' (ie comparison essential here) **DO NOT ALLOW** 'no intermolecular forces'

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Question			Expected Answers	Marks	Additional Guidance
	(c)		van der Waals' forces **OR** induced dipole interactions ✓ number of electrons increases ✓ **Down the group**, intermolecular forces / van der Waals' forces increase **OR** **Down the group**, more energy needed to break intermolecular / van der Waals' forces ✓	3	**electron(s) must be seen and spelt correctly ONCE** **ALLOW** number of electron shells increases **ALLOW** iodine has most electrons **ALLOW** chlorine has the least electrons For **'Down the group'** **ALLOW** 'Increase in boiling points' or 'Molecules get bigger'
	(d)	(i)	goes brown ✓	1	**ALLOW** yellow **OR** orange **OR** any shade of yellow, orange and brown, *e.g.* reddish-brown **IGNORE** precipitate
		(ii)	iodine and (potassium) chloride ✓ $Cl_2 + 2I^- \longrightarrow I_2 + 2Cl^-$ ✓	2	**DO NOT ALLOW** formulae (*i.e.* names essential) **ALLOW** any correct multiple including fractions **IGNORE** state symbols
		(iii)	chlorine / Cl_2 is more reactive (than iodine) **OR** chlorine / Cl_2 is a more powerful oxidising agent ✓	1	**ALLOW** chlorine is better at electron capture **OR** chlorine attracts electrons more **ALLOW** iodine is less reactive (than chlorine) **ALLOW** iodide (ion) / I^- is a stronger reducing agent **DO NOT ALLOW** Cl is more reactive **DO NOT ALLOW** explanation in terms of displacement **DO NOT ALLOW** chlorine is more electronegative
		(iv)	goes purple / violet / lilac / pink ✓	1	**ALLOW** pink **OR** any combination of purple, violet, lilac and pink
			Total	15	

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THIS IS A NEW SPECIFICATION

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ADVANCED SUBSIDIARY GCE
CHEMISTRY A
Atoms, Bonds and Groups

F321

Candidates answer on the question paper

OCR Supplied Materials:
- *Data Sheet for Chemistry A* (Inserted)

Other Materials Required:
- Scientific calculator

Friday 9 January 2009
Afternoon

Duration: 1 hour

CUP/T73721

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

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3	14	
4	8	
5	12	
TOTAL	60	

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Answer **all** the questions.

1 Carbon occurs in a wide range of compounds and is essential to living systems.

(a) Two isotopes of carbon are ^{12}C and ^{13}C.

(i) State what is meant by the term *isotopes*.

.....

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

(ii) Isotopes of carbon have the same chemical properties.

Explain why.

.....

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

(iii) The ^{12}C isotope is used as the standard measurement of relative masses.

Define the term *relative isotopic mass*.

.....

.....

.....

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

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(b) One form of naturally occurring carbon is graphite.

The table below lists some properties of graphite.

electrical conductivity	good conductor
hardness	soft
melting point	very high

- Describe the bonding and structure in graphite.
- Explain, in terms of bonding and structure, the properties of graphite shown above.



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

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..... **[5]**

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(c) In the sixteenth century, a large deposit of graphite was discovered in the Lake District.

People at the time thought that the graphite was a form of lead.

Nowadays, graphite is used in pencils but it is still referred to as 'pencil lead'.

A student decided to investigate the number of carbon atoms in a 'pencil lead'. He found that the mass of the 'pencil lead' was 0.321 g.

(i) Calculate the amount, in mol, of carbon atoms in the student's pencil lead.

Assume that the 'pencil lead' is pure graphite.

answer = ... mol **[1]**

(ii) Using the Avogadro constant, N_A, calculate the number of carbon atoms in the student's 'pencil lead'.

number of carbon atoms = ... **[1]**

[Total: 11]

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2 Chemists have developed models for bonding and structure which are used to explain different properties.

(a) Ammonia, NH_3, is a covalent compound.

(i) Explain what is meant by a *covalent bond*.

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

(ii) Draw a '*dot-and-cross*' diagram to show the bonding in NH_3.

Show **outer** electrons only.

[1]

(iii) Name the shape of the ammonia molecule.

Explain, using your '*dot-and-cross*' diagram, why ammonia has this shape and has a bond angle of 107°.

shape: .....

explanation: .....

.....

.....

.....

.....

.....

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

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(b) Ammonia reacts with hydrogen chloride, HC*l*, to form ammonium chloride, NH_4Cl.

NH_4Cl is an ionic compound containing NH_4^+ and Cl^- ions.

(i) Complete the electron configuration of the Cl^- ion.

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

(ii) Draw a '*dot-and-cross*' diagram to show the bonding in NH_4^+.

Show **outer** electrons only.

[1]

(iii) State the shape of, and bond angle in, an NH_4^+ ion.

shape: .....

bond angle: ..... **[2]**

(iv) A student investigated the conductivity of ammonium chloride.

She noticed that when the ammonium chloride was solid it did **not** conduct electricity. However, when ammonium chloride was dissolved in water, the resulting solution did conduct electricity.

Explain these observations.

.....

.....

.....

.....

.....

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

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(c) Ammonium compounds such as ammonium sulfate, $(NH_4)_2SO_4$, can be used as fertilisers.

(i) Write a balanced equation to show how ammonium sulfate could be formed by the reaction between aqueous ammonia and sulfuric acid.

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

(ii) Ammonium sulfate is an example of a salt formed when an acid is neutralised by a base.

Explain what is meant by the term *salt*.

.....

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

(iii) Why is ammonia acting as a base in this neutralisation?

.....

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

(iv) What is the relative formula mass of $(NH_4)_2SO_4$?

Give your answer to **one** decimal place.

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

[Total: 15]

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3 A student used the internet to research chlorine and some of its compounds.

(a) He discovered that sea water contains chloride ions. The student added aqueous silver nitrate to a sample of sea water.

(i) What would the student see?

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

(ii) Write an ionic equation, including state symbols, for the reaction that would occur.

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

(iii) After carrying out the test in **(i)**, the student added dilute aqueous ammonia to the mixture.

What would the student see?

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

(b) The student also discovered that chlorine, Cl_2, is used in the large-scale treatment of water.

(i) State **one** benefit of adding chlorine to water.

.....

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

(ii) Not everyone agrees that chlorine should be added to drinking water.

Suggest **one** possible hazard of adding chlorine to drinking water.

.....

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

(c) The equation for the reaction of chlorine with water is shown below.

$$Cl_2(g) + H_2O(l) \rightarrow HCl(aq) + HClO(aq)$$

(i) State the oxidation number of chlorine in:

Cl_2 ..... HCl ..... HClO ..... **[1]**

(ii) The reaction of chlorine with water is a *disproportionation* reaction.

Use the oxidation numbers in **(i)** to explain why.

.....

.....

.....

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

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(iii) Chlorine reacts with sodium hydroxide to form bleach in another disproportionation reaction.

Write an equation for this reaction.

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

(d) Two other chlorine compounds of chlorine are chlorine dioxide and chloric(V) acid.

(i) Chlorine dioxide, ClO_2, is used as a bleaching agent in both the paper and the flour industry. When dry, ClO_2 decomposes explosively to form oxygen and chlorine.

Construct an equation for the decomposition of ClO_2.

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

(ii) Chloric(V) acid has the following percentage composition by mass:

H, 1.20%; Cl, 42.0%; O, 56.8%.

Using this information, calculate the empirical formula of chloric(V) acid.

Show **all** of your working.

empirical formula = ... **[2]**

(iii) What does (V) represent in chloric(V) acid?

.....

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

[Total: 14]

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4 The table below shows the melting points and atomic radii of the elements in Period 3, Na to C*l*.

element	Na	Mg	A*l*	Si	P	S	C*l*
melting point/°C	98	639	660	1410	44	113	–101
atomic radius/pm	186	160	143	118	110	102	99

$1\,pm = 1 \times 10^{-12}\,m$

(a) (i) Explain the difference in melting point for the elements Na and Mg.

.....

.....

.....

.....

.....

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

(ii) Sulfur exists as S_8 molecules and chlorine as Cl_2 molecules. Use this information to explain the difference in their melting points.

.....

.....

.....

.....

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

(b) Explain the decrease in the atomic radii across the period from Na to C*l*.

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

.....

.....

.....

.....

.....

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

[Total: 8]

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5 The Group 2 element barium, Ba, is silvery white when pure but blackens when exposed to air. The blackening is due to the formation of both barium oxide and barium nitride. The nitride ion is N^{3-}.

(a) Predict the formula of:

barium oxide ..... barium nitride ..... **[2]**

(b) A 0.11 g sample of pure barium was added to 100 cm^3 of water.

$$Ba(s) + 2H_2O(l) \longrightarrow Ba(OH)_2(aq) + H_2(g)$$

(i) Show that 8.0×10^{-4} mol of Ba were added to the water.

[1]

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

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

(iii) Calculate the concentration, in mol dm^{-3}, of the $Ba(OH)_2(aq)$ solution formed.

concentration = ... mol dm^{-3} **[1]**

(iv) State the approximate pH of the $Ba(OH)_2(aq)$ solution.

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

TURN OVER FOR QUESTION 5(c) AND 5(d)

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(c) A student repeated the experiment in **(b)** using a 0.11 g sample of barium that had blackened following exposure to the air.

Suggest why the volume of hydrogen produced would be slightly less than the volume collected using pure barium.

.....

.....

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

(d) Describe and explain the trend, down the group, in the reactivity of the Group 2 elements with water.

.....

.....

.....

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..... **[5]**

[Total: 12]

END OF QUESTION PAPER

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GCE

Chemistry A

Advanced GCE **A2 H434**

Advanced Subsidiary GCE **AS H034**

Mark Schemes for the Units

January 2009

H034/H434/MS/R/09J

Oxford Cambridge and RSA Examinations

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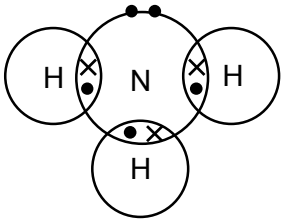
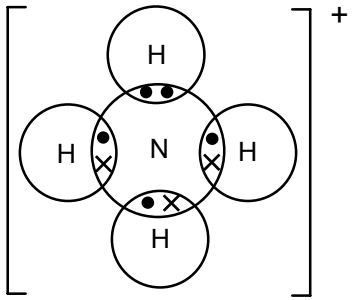
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Question			Expected Answers	Marks	Additional Guidance
					ALLOW 12C **OR** C12 **ALLOW FOR 2 MARKS:** $\frac{\text{mass of the isotope}}{\text{mass of 1/12th mass of carbon - 12}}$ i.e. fraction is equivalent to 'compared to' **ALLOW 1 MARK FOR** a mix of mass of atom and mass of mole of atoms**, i.e.:** 'mass of the isotope/mass of an atom compared with 1/12th the mass of a **mole OR** 12 g of carbon-12.'
	b		giant covalent (lattice) ✓ layers ✓ **Each of the three properties below must be linked to explanation** *good conductor* - because it has mobile electrons **OR** delocalised electrons **OR** electrons can move ✓ *high melting / boiling point* - because strong **OR** covalent bonds have to be broken ✓ *soft* - because there are van der Waals' forces **OR**	**5**	**Use annotations with ticks, crosses etc. for this part.** **All five marking points are independent** **ALLOW** giant atomic **OR** giant molecular **OR** macromolecular **ALLOW** planes **OR** sheets Allow diagram showing at least two layers **Electron(s) must be spelt correctly ONCE** **DO NOT ALLOW** 'strong ionic bonds' **OR** strong metallic bonds.

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Question			Expected Answers	Marks	Additional Guidance
			intermolecular forces **OR** weak bonds **OR** weak forces between the layers **OR** *soft* - because layers can slide ✓		
	c	**i**	0.0268 **OR** 0.027 **OR** 0.02675 mol ✓	**1**	**NO OTHER ACCEPTABLE ANSWER**
		ii	1.61×10^{22} ✓	**1**	**ALLOW** 1.6×10^{22} up to calculator value **ALLOW** **ECF** answer to **(i)** × 6.02×10^{23} **ALLOW** any value for N_A in the range: $6.0 \times 10^{23} – 6.1 \times 10^{23}$
			Total	**11**	

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Question			Expected Answers	Marks	Additional Guidance
2	a	i	a shared pair of electrons ✓	1	**ALLOW** any response that communicates electron pair **ALLOW** shared pairs
		ii	 ✓	1	Must be '*dot-and-cross*' circles for outer shells **NOT** needed **IGNORE** inner shells Non-bonding electrons of N do not need to be shown as a pair.
		iii	Shape: pyramidal **OR** (trigonal) pyramid ✓ Explanation: There are 3 bonded pairs and 1 lone pair ✓ Lone pairs repel more than bonded pairs ✓	3	 **ALLOW** 'bonds' for 'bonded pairs' **DO NOT ALLOW** 'atoms repel' **DO NOT ALLOW** electrons repel **ALLOW** LP for 'lone pair' **ALLOW** BP for bonded pair
	b	i	$1s^2 2s^2 2p^6 3s^2 3p^6$ ✓	1	**ALLOW** subscripts
		ii	 '*Dot-and-cross*' diagram to show four shared pairs of electrons one of which is a dative covalent bond (which must consist of the same symbols) ✓	1	**IGNORE** inner shells **IGNORE** '+' sign **BUT** a **DO NOT ALLOW** '–' sign. Brackets and circles not required

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Question			Expected Answers	Marks	Additional Guidance
		iii	tetrahedral ✓ 109.5º ✓	2	**ALLOW** 109–110º
		iv	ions **OR** electrons cannot move in a solid ✓ **ions** can move **OR** are mobile in solution ✓	2	**ALLOW** ions can move in liquid **DO NOT ALLOW** ions can move when molten **ALLOW 1 mark for:** 'Ions can only move in solution'
	c	i	$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$ ✓	1	**ALLOW** $2NH_4OH + H_2SO_4 \rightarrow (NH_4)_2SO_4 + 2H_2O$ **ALLOW** $NH_3 + H^+ \rightarrow NH_4^+$ **ALLOW** any correct multiple **IGNORE** state symbols
		ii	when the H^+ in an acid is replaced by a metal ion **OR** an ammonium ion **OR** a + ion ✓	1	**ALLOW** H for H^+; **ALLOW** 'metal' for 'metal ion **i.e.:** H in an acid can be replaced by a metal
		iii	accepts a proton **OR** accepts H^+ ✓	1	**ALLOW** donates a lone pair **ALLOW** removes H^+ **ALLOW** forms OH^- ions
		iv	132.1 ✓	1	**IGNORE** units **NO OTHER ACCEPTABLE ANSWER**
			Total	15	

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Question			Expected Answers	Marks	Additional Guidance
3	a	i	white precipitate **OR** white solid ✓	1	**DO NOT ALLOW** goes white / cloudy / milky / off-white **DO NOT ALLOW** creamy white precipitate **ALLOW** milky white precipitate
		ii	$Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$ Balanced equation correct ✓ **ALL** state symbols correct ✓	2	**ALLOW 2 marks** $AgNO_3(aq) + Cl^-(aq) \longrightarrow AgCl(s) + NO_3^-(aq)$ **(equation mark and state symbol mark)** **ALLOW 1 mark for:** $AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$ **(state symbol mark)** **ALLOW 1 mark for the state symbols for THESE balanced equation ONLY:** $Ag^{2+}(aq) + 2Cl^-(aq) \longrightarrow AgCl_2(s)$ $Ag(aq) + Cl(aq) \longrightarrow AgCl(s)$
		iii	(precipitate) dissolves **OR** disappears **OR** goes colourless **OR** goes clear ✓	1	**ALLOW** forms a solution
	b	i	removes or kills bacteria **OR** kills germs **OR** kills micro-organisms **OR** make it safe to drink **OR** sterilises water ✓	1	**ALLOW** to make water potable **IGNORE** virus **DO NOT ALLOW** 'purifies water' **DO NOT ALLOW** 'antiseptic'
		ii	it is toxic **OR** poisonous **OR** could form chlorinated hydrocarbons ✓	1	**ALLOW forms** carcinogens **OR** forms toxins **DO NOT ALLOW** harmful **DO NOT ALLOW 'it causes cancer'** (chlorine is not a carcinogen) **DO NOT ALLOW 'irritates lungs'**
	c	i	Cl_2 is 0 **AND** HCl is –1 **AND** HClO is (+)1 ✓	**1**	**ALLOW** 1– **ALLOW** 1+

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Question			Expected Answers	Marks	Additional Guidance
		ii	It has been both oxidised and reduced **OR** Its oxidation state has increased and decreased ✓ it has been oxidised (from 0) to +1 **AND** it has been reduced (from 0) to –1 ✓ (These two points together subsume the first marking point)	2	**ALLOW** 'chlorine' **OR** 'it' **DO NOT ALLOW** chlor**IDE** **IF CORRECT OXIDATION STATES IN (i), ALLOW 2 marks for:** it is oxidised to form HClO it is reduced to form HCl
		iii	$Cl_2 + 2NaOH \rightarrow NaClO + NaCl + H_2O$ ✓	1	**IGNORE** state symbols
	d	i	$2ClO_2 \rightarrow Cl_2 + 2O_2$ **OR** $ClO_2 \rightarrow ½Cl_2 + O_2$ ✓	1	**IGNORE** state symbols
		ii	divides each % by correct A_r: i.e. $\frac{1.20}{1.0} : \frac{42.0}{35.5} : \frac{56.8}{16.0}$ **OR** 1.20, 1.18, 3.55 ✓ $HClO_3$ ✓	2	**ALLOW 1 mark** for empirical formula of HCl_2O_6 (use of atomic numbers) **ALLOW 1 mark** for empirical formula of H_3Cl_3O (upside-down expression) **ALLOW ECF** for use of incorrect A_r values to get empirical formula but only if no over-rounding **ALLOW 2 marks** for correct answer of $HClO_3$
		iii	the oxidation number of chlorine ✓	1	**ALLOW** 'the oxidation state of chlorine **OR** oxidation number of chlorine is 5' **DO NOT ALLOW** 'it' instead of 'chlorine' **DO NOT ALLOW** 'the oxidation state **OR** number of chlor**IDE** is 5'
			Total	14	

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Question			Expected Answers	Marks	Additional Guidance
4	a	i	Magnesium ions have a greater charge✓ Magnesium has more (delocalised **OR** outer) **electrons**✓ Magnesium has greater attraction between **ions** and **electrons OR** has stronger **metallic** bonds ✓	3	***USE annotations with ticks, crosses, ecf, etc for this part.*** **ALLOW REVERSE ARGUMENT** e.g. sodium ions have a smaller charge **ALLOW** Mg^{2+} / Mg ion / Na ion / Na^{+} ion **ALLOW** 'charge density' as alternative to 'charge' **ALLOW REVERSE ARGUMENT** e.g. sodium has fewer electrons **ALLOW REVERSE ARGUMENT** e.g. sodium has less attractions between **ions** and **electrons** **OR** has weaker **metallic** bonds ✓
		ii	Cl_2 **OR** S_8 has intermolecular **OR** van der Waals' forces ✓ S_8 has stronger intermolecular forces **OR** van der Waals' forces than Cl_2 **OR** S_8 has more electrons ✓	2	**ALLOW REVERSE ARGUMENT** ie Cl_2 has weaker intermolecular forces **OR** van der Waals' forces **DO NOT ALLOW** comparison involving covalent bonds **ALLOW REVERSE ARGUMENT** Cl_2 has fewer electrons

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Question			Expected Answers	Marks	Additional Guidance
	b			3	***USE annotations with ticks, crosses, ecf, etc for this part.***
			nuclear charge increases/ protons increase ✓		**Nuclear OR proton(s) OR nucleus spelt correctly ONCE** **IGNORE** 'atomic number increases' **IGNORE** 'nucleus gets bigger' 'charge increases' is not sufficient **ALLOW** 'effective nuclear charge increases' **OR** 'shielded nuclear charge increases'
			electrons added to the same shell **OR** screening **OR** shielding remains the same ✓		**IGNORE** reference to atomic radius staying the same
			greater attraction **OR** greater pull ✓		**ALLOW** shielding is similar **DO NOT ALLOW** extra shielding A comparison **must** be included: i.e. '**greater** pull', '**more** pull', 'held **more** tightly';
			Total	**8**	

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Question			Expected Answers	Marks	Additional Guidance
5	a		BaO ✓ Ba_3N_2 ✓	2	Treat any shown charges as working and ignore. Treat B for Ba as a slip.
	b	i	$\frac{0.11}{137.3}$ ✓	1	mark is for the **working out** which **MUST** lead to the correct answer of 8 x 10^{-4} up to calculator value
		ii	19.2 **OR** calculated answer to **(b)(i)** x 24000 ✓	1	**ALLOW** 19 up to calculator value.
		iii	8.0 x 10^{-3} **OR** calculated answer to **(b)(i)** x 10 ✓	1	**ALLOW** 8.01 x 10^{-3} up to calculator value.
		iv	any pH > 7 but <15 ✓	1	**ALLOW** a correct range of pH.
	c		Less barium to react **OR** some barium has already reacted ✓	1	**ALLOW** less volume because contains some BaO or Ba_3N_2
	d		reactivity increases (down the group) ✓ atomic radii increase **OR** there are more shells ✓ there is **more** shielding **OR more** screening ✓ the nuclear attraction decreases **OR** Increased shielding and distance outweigh the increased nuclear charge ✓ easier to remove (outer) electrons **OR** ionisation energy decreases ✓	5	***USE annotations with ticks, crosses, ecf, etc for this part.*** **DO NOT ALLOW** more orbitals **OR** more sub-shells '**More'** *is essential* **ALLOW** 'more electron repulsion from inner shells' **ALLOW** 'nuclear pull' **IGNORE** any reference to 'effective nuclear charge' **ALLOW** easier to form positive ion
			Total	12	

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