



GCE

Chemistry A

Advanced Subsidiary GCE

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

Mark Scheme for January 2012

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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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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).

| Question | | | Answer | Marks | Guidance | | | | | | | | | |
|------------|---------|----------|---|-------|--|----------|------------|----|----|------------|----|----|---|--|
| 1 | (a) | (i) | <p>mass of the isotope compared to 1/12th OR mass of the atom compared to 1/12th ✓ (the mass of a ¹²C (atom) ✓</p> | 2 | <p>ALLOW for ¹²C: carbon-12 OR C-12 OR C 12 OR 12 C</p> <p>IGNORE reference to average OR weighted mean (ie correct definition of relative atomic mass scores both marks)</p> <p>ALLOW mass of a mole of the isotope/atom with 1/12th ✓ the mass of a mole OR 12 g of carbon-12 ✓</p> <p>ALLOW 2 marks for: 'mass of the isotope OR mass of the atom compared to ¹²C atom given a mass of 12.0' ie 'given a mass of 12' communicates the same idea as 1/12th'</p> <p>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'</p> <p>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'</p> <p>DO NOT ALLOW mass of ion OR mass of element BUT ALLOW mass of an atom of an element</p> | | | | | | | | | |
| | | (ii) | <p>Both rows completed correctly ✓</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th></th> <th>protons</th> <th>neutrons</th> </tr> </thead> <tbody> <tr> <td>iodine-127</td> <td>53</td> <td>74</td> </tr> <tr> <td>iodine-131</td> <td>53</td> <td>78</td> </tr> </tbody> </table> | | protons | neutrons | iodine-127 | 53 | 74 | iodine-131 | 53 | 78 | 1 | <p>ALL four entries in table correct for 1 mark</p> |
| | protons | neutrons | | | | | | | | | | | | |
| iodine-127 | 53 | 74 | | | | | | | | | | | | |
| iodine-131 | 53 | 78 | | | | | | | | | | | | |

| Question | | | Answer | Marks | Guidance |
|----------|-----|------|---|-------|---|
| 1 | (b) | (i) | <p>FIRST CHECK THE ANSWER ON ANSWER LINE IF answer = 91.6 (µg), must be 3 sf, award 2 marks</p> <p>Amount of I⁻ mark: = 70.0 x 10⁻⁶ /126.9 OR = 5.52 x 10⁻⁷ ✓ (mol)</p> <p>Mass of KI = (5.52 x 10⁻⁷/10⁻⁶) x 166.0 = 91.6 (µg) must be 3 sf ✓</p> | 2 | <p>If there is an alternative answer, check to see if there is any ECF credit possible FOR ONE MARK ONLY using working below</p> <p>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</p> <p>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.</p> <p>Answers with 91.6 x 10^{-x} (ie wrong conversion of µg and g) would get one mark</p> |
| | | (ii) | <p>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 ✓</p> | 1 | <p>ALLOW some people disapprove of additives in their food</p> <p>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'</p> <p>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</p> |
| | (c) | (i) | $Cl_2 + 2I^- \rightarrow 2Cl^- + I_2 \checkmark$ | 1 | IGNORE state symbols |

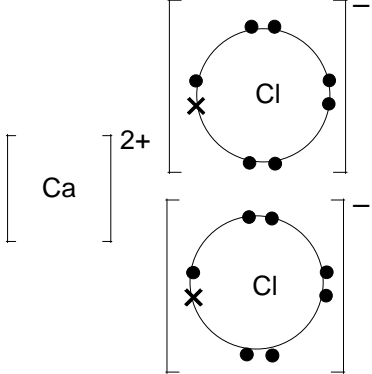
| Question | | | Answer | Marks | Guidance |
|----------|-----|------|---|----------|--|
| 1 | (c) | (ii) | <p>Two alternative explanations to award the two marks:</p> <p><i>Explanation 1</i> ICl has permanent dipole (–dipole) (interactions) AND Cl₂ has (only) van der Waals' forces ✓</p> <p>Forces are stronger in ICl ORA OR More energy is needed to overcome forces in ICl ✓ ORA</p> <p><i>Explanation 2</i> ICl has more electrons ✓ ORA</p> <p>Stronger van der Waals' forces in ICl (than in Cl₂) ORA OR More energy is needed to overcome van der Waals' forces in ICl ✓ ORA</p> | 2 | <p>Quality of Written Communication: 'dipole' OR 'permanent' spelled correctly at least once and in context for marking point 1 in explanation 1</p> <p>ALLOW 'vdW' for van der Waals' IGNORE references to van der Waals' forces in ICl in explanation 1 DO NOT ALLOW 'dipole–dipole interactions' without reference to these being permanent for marking point 1</p> <p>DO NOT ALLOW marking point 2 for comparison of ICl having stronger ionic OR covalent bonds than Cl₂</p> <p>Quality of Written Communication – 'electrons' spelled correctly once and used in context for marking point 1 of explanation 2</p> <p>ALLOW I has more electrons</p> <p>ALLOW more van der Waals' forces ALLOW 'vdW' for van der Waals'</p> |
| | | | Total | 9 | |

| 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 $\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$ ✓ | 2 | ALLOW $\text{CaCl}_2(\text{H}_2\text{O})_6$ ALLOW $\text{CaCl}_2 6\text{H}_2\text{O}$ (ie no 'dot') ALLOW $[219.1 - (40.1 + 2 \times 35.5)] / 18$ AND $\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$ for two marks ALLOW ECF for incorrectly calculated mass of $\text{H}_2\text{O} / 18$ provided final answer is rounded to nearest whole number for marking point 2 |

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| Question | | Answer | Marks | Guidance |
|--------------|-----|--|-----------|---|
| 2 | (d) |  <p>Ca shown with either 8 or 0 electrons AND Cl shown with 8 electrons with 7 crosses and one dot (or vice versa) ✓</p> <p>correct charges on both sets of ions ✓</p> | 2 | <p>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</p> <p>ALLOW One mark if both electron arrangement and charges are correct but only one Cl is drawn</p> <p>ALLOW 2[Cl⁻] 2[Cl]⁻ [Cl⁻]₂ (brackets not required) DO NOT ALLOW [Cl₂]⁻ [Cl₂]²⁻ [2Cl]²⁻ [Cl]₂⁻</p> |
| | (e) | <p>Ba is more reactive than Ca ✓ ORA</p> <p>Br₂ is less reactive than Cl₂ ✓ ORA</p> | 2 | <p>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 Cl and Br have been identified as Group 7 elements ALLOW one mark for both sentences if no ascribing to groups</p> <p>ALLOW Br for Br₂ and Cl for Cl₂ DO NOT ALLOW Br⁻ for Br₂ OR Cl⁻</p> |
| Total | | | 11 | |

| 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 |

| Question | | Answer | Marks | Guidance |
|--------------|---------|--|-----------|---|
| 3 | (d) (i) | <p>From F to Ne <i>Nuclear charge mark:</i> Ne has (one) more proton OR Nuclear charge increases ✓</p> <p><i>Same shell or energy level mark:</i> (Outermost) electrons are in the same shell OR energy level OR (Outermost) electrons experience the same shielding ✓</p> <p><i>Nuclear attraction mark:</i> Greater nuclear attraction (on outermost electrons) OR Outer electrons are attracted more strongly (to the nucleus) ✓</p> | 3 | <p>Use annotations with ticks, crosses, ECF etc for this part</p> <p>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'</p> <p>ALLOW sub-shell for shell but IGNORE orbitals</p> <p>ALLOW shielding is similar ALLOW screening for shielding IGNORE Atomic radius decreases (<i>because given in question</i>) OR outermost electrons are closer DO NOT ALLOW 'distance is the same' for second mark</p> <p>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'</p> |
| | (ii) | <p>From Ne to Na <i>Extra shell or energy level mark:</i> Na has (one) more shell(s) OR energy level ✓</p> <p><i>Shielding mark:</i> (Outermost) electron experiences greater shielding ✓</p> <p><i>Nuclear attraction mark:</i> Less nuclear attraction (on outermost electrons) OR Outer electrons are attracted less strongly (to nucleus) ✓</p> | 3 | <p>Use annotations with ticks, crosses, ECF etc for this part</p> <p>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 (<i>because given in question</i>) DO NOT ALLOW orbitals OR sub-shells</p> <p>ALLOW screening for shielding ALLOW more electron repulsion from inner shells</p> <p>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</p> |
| Total | | | 13 | |

| Question | | Answer | | | Marks | Guidance | | |
|----------|-----|---|------------------|---------------------------|-------|---|---|--------------------|
| 4 | (a) | | solid | melting point / °C | | 2 | giant AND ionic required simple AND molecular required ALLOW simple covalent | |
| | | | K | 63 | | | | |
| | | | KBr | 734 | | | | giant ionic ✓ |
| | | | H ₂ O | 0 | | | | simple molecular ✓ |
| | (b) | <p><i>Particle mark 1:</i> In K, (electrostatic attraction between) positive ions/cations AND e⁻ / electrons ✓</p> <p><i>Particle mark 2:</i> In KBr, (electrostatic attraction between) oppositely OR positively AND negatively charged ions ✓</p> <p><i>Forces mark:</i> 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 ✓</p> <p><i>In H₂O,</i> <i>Forces mark:</i> hydrogen bonding ✓</p> <p><i>Particles mark (QWC):</i> (Between) molecules ✓</p> <p>Order of strength of forces: KBr > K > H₂O OR ionic bonding > metallic bonding > hydrogen bonding ✓</p> | | | 6 | <p>Use annotations with ticks, crosses, ECF etc for this part</p> <p>ALLOW labels from diagrams if not seen in text</p> <p>ALLOW K⁺ and Br⁻ for 'oppositely charged ions'</p> <p>DO NOT ALLOW 'atoms' in KBr</p> <p>IGNORE 'metallic lattice' for metallic bonding' AND 'ionic lattice' for 'ionic bonding'</p> <p>DO NOT ALLOW , for forces mark, incorrect forces for K and KBr, such as covalent, van der Waals' seen anywhere in the response</p> <p>IGNORE references to van der Waals' forces in water</p> <p>ALLOW 'intermolecular' OR 'molecular' for particles mark <i>Quality of Written Communication:</i> 'molecules' OR 'intermolecular' OR 'molecular' spelt correctly once and used in context for the fifth marking point</p> <p>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 > H₂O IGNORING incorrect forces used above</p> | | |

| Question | | Answer | Marks | Guidance |
|--------------|-----|---|-----------|--|
| 4 | (c) | <p>FIRST CHECK THE ANSWER ON ANSWER LINE IF answer = 72(.0) (cm³) award 3 marks</p> <p>amount of K = 0.2346 / 39.1 OR = 6.(00) × 10⁻³ OR 0.006(00) mol ✓</p> <p>amount of H₂ = (mol of K) / 2 OR = 3.(00) × 10⁻³ OR 0.003(00) mol ✓</p> <p>Volume of gas = (mol of H₂) × 24000 OR = 72(.0) (cm³) ✓</p> | 3 | <p>If there is an alternative answer, check to see if there is any ECF credit possible using working below</p> <p>ALLOW mol of K x 0.5 correctly calculated for 2nd mark</p> <p>ALLOW mol of H₂ x 24000 correctly calculated for 3rd mark</p> <p>ALLOW 144 (cm³) from 0.006 x 24000 for two marks ALLOW 0.072 from 0.003 x 24 for two marks</p> <p>ALLOW calculator value or rounding to 2 significant figures or more BUT IGNORE 'trailing' zeroes, eg 0.200 allowed as 0.2</p> |
| Total | | | 11 | |

| 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 ₂ SO ₄ = 0.100 × 32.5/1000 = 3.25 × 10 ⁻³ OR 0.00325 mol ✓ Amount of NH ₃ = (mol of H ₂ SO 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 ₂ SO 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 × 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 107° ✓ <i>Explanation</i> There are 3 bonded pairs and 1 lone pair ✓ Electron pairs repel ✓ Lone pairs repel more than bonded pairs ✓ | 4 | ALLOW range 106–108° 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 $\text{N}_2\text{H}_6^{2+}$ ✓ | 1 | ALLOW $\text{H}_2\text{N}-\text{NH}_3^+$ OR $\text{H}_3\text{N}-\text{NH}_3^{2+}$ |
| | (d) | (i) | Cl goes from (+)1 to -1 ✓ N goes from -3 to -2 ✓ Cl is reduced AND N is oxidised ✓ | 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 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 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 $2\text{NH}_3 + \text{NaClO} \rightarrow \text{N}_2\text{H}_4 + \text{NaCl} + \text{H}_2\text{O}$ |
| | | (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) | $\text{N}_2\text{H}_4 + 2\text{NH}_2\text{Cl} \rightarrow 2\text{NH}_4\text{Cl} + \text{N}_2$ ✓✓ | 2 | One mark for N_2 One mark for NH_4Cl AND balancing |
| Total | | | | 16 | |

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