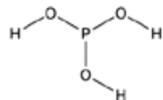


Mark scheme

| Question | Answer/Indicative content | Marks | Guidance |
|----------|--|-------|---|
| 1 | <p>i</p> <p>In (Equilibrium) 1,</p> <p>H_2PO_4^-/It acts as a base AND accepts/gains H^+/a proton OR H_2PO_4^- forms H_3PO_4 ✓</p> <p>In (Equilibrium) 2,</p> <p>H_2PO_4^-/It acts as an acid, AND donates/loses H^+/a proton OR H_2PO_4^- forms HPO_4^{2-} ✓</p> | 2 | <p>ALLOW description for 1 or 2 as long as unambiguous, e.g. Equation 1, etc</p> <p>IGNORE missing charge on H_2PO_4^- throughout</p> <p>IGNORE reference to $\text{H}_2\text{PO}_4^{2-}$ acting as an acid/base OR Equilibrium 3 <i>Question is about H_2PO_4^-</i></p> <p>ALLOW 'dissociates into H^+ and $\text{H}_2\text{PO}_4^{2-}$' IGNORE 'partially'</p> <p><u>Examiner's Comments</u></p> <p>Candidates were expected to link proton-transfer behaviour in acids and bases to the provided equilibria. The question differentiated between candidates well.</p> <p>Some candidates just stated that an acid is a proton donor and a base a proton acceptor without referring to the provided equilibria. This was the answer to a much simpler question and could not be given marks.</p> <p>The best responses demonstrated excellent understanding within the context of the equilibria. Such candidates clearly explained how H_2PO_4^- behaves as an acid in the forward reaction of Equilibrium 2 and as a base in the reverse reaction of Equilibrium 1.</p> |
| | <p>ii</p> <p>Diagram showing all bonds correctly ✓</p> | 3 | <p>IGNORE geometry</p> <p>ALLOW dot and cross diagram</p> |



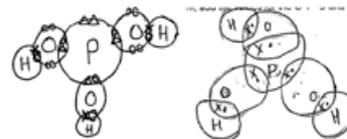
- 3 bonds only around each P
- 2 bonds only around each O
- Each O bonded to an H

Bond angles

$$\text{O-P-O} = 107^\circ \checkmark$$

$$\text{P-O-H} = 104.5^\circ \checkmark$$

showing 2 shared electrons for each bond
..... and **IGNORE** any lone pairs
e.g.



Unambiguous bond angles may be shown on dot and cross diagram

ALLOW 106-108°

ALLOW 104-105°

Examiner's Comments

Most candidates used the information in the question to draw a correct displayed formula of H_3PO_3 . Another acceptable approach was to show a 'dot-and-cross' diagram.

Candidates usually chose 104.5° for the P-O-H bond angles although a significant number suggested 180° . The O-P-O bond angle proved to be more difficult. Many suggested 120° by ignoring the lone pair of electrons on the P atom. The shape was analogous with NH_3 giving a bond angle of 107° .

Overall, candidates answered this question well. Candidates are advised to assess the number of bonded pairs and lone pairs around each atom when suggesting bond angles. This would have reduced the number of incorrect bond angles such as 180° for P-O-H and 120° for O-P-O.

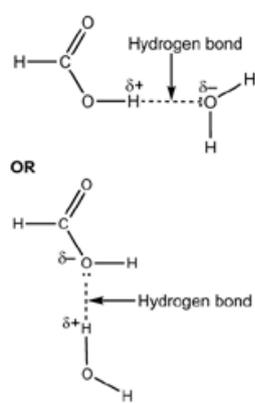
iii

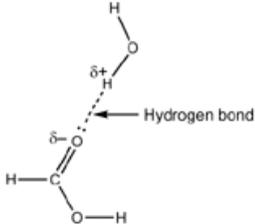
phosphoric(III) **acid** ✓
Oxidation number **MUST** be in correct place

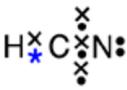
1

DO NOT ALLOW phosphoric acid (III)

DO NOT ALLOW phosphorous

| | | | | |
|---|--|--|---|---|
| | | | | acid |
| | | | | <p>Examiner's Comments</p> <p>Most candidates wrote the correct systematic name of phosphorus(III) acid and the clue given in the question for the name of H_3PO_4 should have helped.</p> <p>Common errors included phosphorus(IV) acid, the same as for H_3PO_4, and the (III) oxidation number being placed after 'acid' in the name. The commonest error though, was hydrogen phosphate.</p> <p>Candidates are advised to use any information provided in the question, which often contains clues. This certainly would have prevented hydrogen phosphate as a response.</p> |
| | | Total | 6 | |
| 2 | | <p>Diagram showing a hydrogen bond between a water molecule and a HCOOH (<i>dipoles and lone pairs not required</i>)</p> <p>AND</p> <p>Hydrogen bonding / H-bond stated OR labelled on diagram ✓</p> |  | <p>ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous</p> <p>ALLOW hydrogen bond to HCOO^- (methanoate ion)</p> <p>DO NOT ALLOW H bond from H-C</p> <p>DO NOT ALLOW any marks for a diagram containing O_2H</p> <p>2 Hydrogen bond does NOT need to be labelled but it must be different from the covalent bond if it is not labelled.</p> <p>IF more than one hydrogen bond is shown they must ALL be correct to award each mark.</p> <p>ALLOW H bond between $\text{C}=\text{O}$ and H_2O, i.e.</p> |
| | | H bond originates from lone pair on δ^- O and goes to δ^+ H (on another molecule) ✓ | | |

| | | | | | |
|---|--|--|--------------|----------|--|
| | | | | |  <p>DO NOT ALLOW $\delta+$ on H atom of C-H All Hydrogen bonds must hit a lone pair ALLOW only one lone pair on O atom DO NOT ALLOW more than 2 lone pairs on O atom</p> <p><u>Examiner's Comments</u></p> <p>Most candidates were able to identify hydrogen bonding as being responsible for the solubility of methanoic acid. A minority of candidates did not gain any marks for this question. Some described the dissociation of methanoic acid into ions in water. Weaker candidates suggested this dissociation was sufficient to explain solubility. Some showed hydrogen bonds from H in the C-H bond in methanoic acid. Some drew hydrogen bonds from H to H or O to O.</p> <p>Most scored the first mark but lost the second mark usually for missing dipoles and/or lone pairs. Candidates often overcomplicated diagrams with multiple hydrogen bonds shown, increasing the likelihood of losing a mark for errors.</p> |
| | | | Total | 2 | |
| 3 | | | C | 1 | <p><u>Examiner's Comments</u></p> <p>Approximately two thirds of candidates gave the correct answer C. The most common incorrect response seen was D,</p> |

| | | | | | |
|---|--|--|--|----------|--|
| | | | | | confusing the strength of the σ and π bonds, possibly as a C=C bond is stronger than C-C. Some gave D assuming alkenes are polar due to their reactivity and showing a misunderstanding of the term 'polar'. |
| | | | Total | 1 | |
| 4 | | | B | 1 | <p><u>Examiner's Comments</u></p> <p>A large majority of candidates were able to correctly identify shape at x as being trigonal planar and y as being tetrahedral. The most common incorrect responses seen were for getting one of these incorrect i.e. D incorrect for x or C incorrect for y.</p> |
| | | | Total | 1 | |
| 5 | | | A | 1 | <p><u>Examiner's Comments</u></p> <p>Nearly all candidates were able to correctly recognise that covalent bonding is the electrostatic attraction between a shared pair of electrons and the nuclei of the bonded atoms. The most common incorrect response was C, confusing it with ionic bonding.</p> |
| | | | Total | 1 | |
| 6 | | |  <p>'Dot and cross' of triple bond correct ✓</p> <p>Complete 'dot and cross' correct ✓</p> | 2 | <p>ALLOW vertical arrangement: x···xx as long as there are 3 electrons of each type</p> <p>ALLOW 2 different symbols, provided that it is clear to which atom the electrons belong, i.e.</p> <ul style="list-style-type: none"> • 5 N electrons • 4 C electrons • 1 H electron |

| | | | | |
|---|---|---|----------|--|
| | | | | <p>The H electron could look the same as the N electrons. Dots could be open or filled.</p> <p><u>Examiner's Comments</u></p> <p>This question was well answered with 'dot-and-cross' diagrams usually correct. Most candidates obtained both marks. The most common error was omission of the nitrogen lone pair.</p> |
| | | Total | 2 | |
| 7 | a | <p>CHECK FOR RESPONSES ON TABLE</p> <p>Trend</p> <p>Boiling point decreases with more branching OR fewer methyl/alkyl groups/side chains ✓</p> <p>Branching and surface contact</p> <p><i>Could be seen anywhere within response</i> Branching linked to the amount of (surface) contact / interaction/overlap (between molecules) ✓</p> <p>Type and strength of intermolecular force</p> <p><i>Could be seen anywhere within response</i> Branching/ boiling points/contact linked to strength of London forces OR induced dipole(-dipole) interactions OR extent of surface contact ✓</p> <p>Energy and intermolecular forces</p> <p><i>Linked to energy seen anywhere</i> More energy to break intermolecular forces with less branching ✓ IGNORE just 'bonds' <i>intermolecular or type of forces required</i></p> | 4 | <p>ANNOTATE WITH TICKS AND CROSSES Comparisons needed throughout <u>ORA</u> throughout</p> <p>ALLOW comparison between 2 alkanes, e.g. C has greatest branching AND lowest boiling point A has no branching AND highest boiling point</p> <p>IGNORE Chain length</p> <p>Surface area alone is not sufficient <i>must have idea of contact.</i></p> <p>DO NOT ALLOW responses comparing different numbers of electrons (as all have the same number).</p> <p>ALLOW more branching results in fewer London forces ORA</p> <p>IGNORE van der Waals'/vdW forces. OR IDID OR IDD</p> <p>ALLOW more energy to break/overcome London forces OR induced dipole(-dipole) interactions</p> |

| | | | <p>OR vdW forces</p> <p>IGNORE harder to overcome/break intermolecular forces (no reference to energy)</p> <p>Examiner's Comments</p> <p>Most candidates were given 3 or 4 marks. The most common omission was the idea of surface contact. Most candidates identified London forces or induced dipole interactions as the relevant intermolecular force. A few candidates gave a general comment in terms of 'intermolecular' forces without specifying the type of intermolecular forces.</p> <p>There has been a general improvement in candidate responses to this type of question with fewer candidates than in previous exams suggesting the breaking of hydrogen bonds or covalent bonds.</p> <p>Exemplar 2</p> <p><i>Refer to the isomers A, B and C in your answer.</i></p> <p><i>Isomers A, B and C have the same molecular formula but different structural formulas. Boiling point decreases down from A to C because there is more branching so fewer surface points of contact. This results in fewer London forces between the molecules so less energy is required to overcome these London forces. (All going down the table from A to C)</i></p> <p>Exemplar 2 shows an excellent response. The explanation is clear and the candidate is aware of the main factors responsible for the trend in boiling points. This response was given the full 4 marks.</p> | | | | | | |
|-------------|------------|--|---|------------|---------------|---|-------|-------------|---|
| b | | <table border="1" data-bbox="228 1865 778 2024"> <thead> <tr> <th>Carbon atom</th> <th>Bond angle</th> <th>Name of shape</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>109.5</td> <td>tetrahedral</td> </tr> </tbody> </table> | Carbon atom | Bond angle | Name of shape | 1 | 109.5 | tetrahedral | <p>ALLOW 109–110 for C1</p> <p>ALLOW 118–122 for C2</p> <p>ALLOW planar triangle</p> <p>ALLOW table responses if in wrong columns</p> |
| Carbon atom | Bond angle | Name of shape | | | | | | | |
| 1 | 109.5 | tetrahedral | | | | | | | |

| | | | |
|---|-----|-----------------|---|
| 2 | 120 | trigonal planar | <p>IGNORE areas of electron density</p> <p>For bonded pairs</p> <p>ALLOW bp, bonded groups, bonded atoms <i>Bonded/bonding essential</i></p> <p>For C2, ALLOW</p> <ul style="list-style-type: none"> • 3 bonded areas/environments • 3 bonded pairs/groups/atoms • 2 bonded pairs and 1 double bond • 2 bonded pairs and 1 bonded region <p>DO NOT ALLOW 'atoms repel'</p> <p>IGNORE</p> <ul style="list-style-type: none"> • electrons repel • bonds repel • electron region OR electron density • lone pairs repel more <i>irrelevant here</i> • shapes, even if wrong <p><u>Examiner's Comments</u></p> <p>The bond angles and shapes rewarded the well-prepared candidates, with many being given both available marks for this part of the question. This part discriminated very well.</p> <p>For the explanation, most candidates identified 4 and 3 for C1 and C2, but candidates often linked 4 and 3 to atoms, rather than to electron pairs or bonded pairs for C1 and to bonding regions for C2.</p> |
| <p>2 OR 3 correct ✓ 4 correct ✓</p> <p>Number of electron pairs</p> <p>In C1/109.5°, 4 bonded pairs/bonding regions/bonds ✓</p> <p>In C2/120°, 3 bonded regions/bonds ✓</p> <p>Electron pair repulsion</p> <p>Electron pairs/bonded pairs repel (as far apart as possible) ✓</p> <p><i>Electron pairs/bonded pairs essential</i> <i>DO NOT ALLOW 'bonded atoms' for this mark</i></p> | | | |

| | | | | | |
|---|--|---|--|----------|--|
| | | | | | <p>A mark was available for stating that 'electron pairs repel', but this important fact was often omitted despite being the main principle that determines molecular shapes.</p> <p>The question discriminated well, giving a good spread of marks across the five available.</p> <p> Misconception</p> <p>Many students think that molecular shapes are determined solely by lone pairs or by repulsion between bonded atoms. The principle behind molecular shapes is called electron pair repulsion theory because it is based on repulsion between electron pairs, which may be bonded pairs or lone pairs, but not atoms.</p> |
| | | | Total | 9 | |
| 8 | | | B | 1 | <p><u>Examiner's Comments</u></p> <p>Most candidates identified CO₂ as the product with linear molecules, suggesting that knowledge of bond shapes is good.</p> |
| | | | Total | 1 | |
| 9 | | i | There are 3 bonding regions OR 3 <u>double bonds</u> (round the S atom). | 1 | <p>ALLOW electron regions / areas of <u>electron density</u></p> <p>ALLOW - It has a resonance structure with all 3 bonds being the same/inbetween a single and double bond OR has 3 σ bonds.</p> <p>DO NOT ALLOW bonding pairs</p> <p><u>Examiner's Comments</u></p> <p>Another challenging question, requiring the identification of 3 double bonds (and no lone pair). The most common error was</p> |

| | | | | | |
|--|--|----|--|---|---|
| | | | | | stating that SO ₂ has 3 bonding pairs – it doesn't, it has 6 bonding pairs which are arranged as 3 double bonds. They could also state that it has 3 bonding regions. |
| | | ii | <p>S/Sulfur and O/Oxygen have different electronegativities (and S–O bonds are polar) ✓</p> <p>(SO₂ lone pair gives) non-linear shape / asymmetrical AND dipoles don't cancel / dipoles do not act in opposite directions OR uneven electron charge density AND dipoles don't cancel ✓</p> | 2 | <p>ALLOW if partial charges are seen on diagram.</p> <p>DO NOT ALLOW sulfur is more electronegative than oxygen</p> <p>For non-linear, ALLOW bent OR v-shaped</p> <p>IGNORE shapes seen in diagrams, treat as rough working IGNORE polar bonds cancel IGNORE polarity cancels DO NOT ALLOW charges cancel</p> <p>ORA e.g. SO₃ trigonal planar shape/symmetrical AND dipoles cancel / dipoles act in opposite directions OR even electron charge density AND dipoles cancel</p> <p><u>Examiner's Comments</u></p> <p>Candidates found this question demanding. Many candidates explained the formation of a polar bond by describing the difference in electronegativity between S and O. Many answers had descriptions about symmetry but explained polarity in terms of polar bonds/charges cancelling instead of dipoles.</p> <p>A symmetric molecule (all bonds identical and no lone pairs) will not be polar even if individual bonds within the molecular are polar. The individual dipoles on the bonds 'cancel out' due to the symmetrical shape of the molecule. There is no</p> |

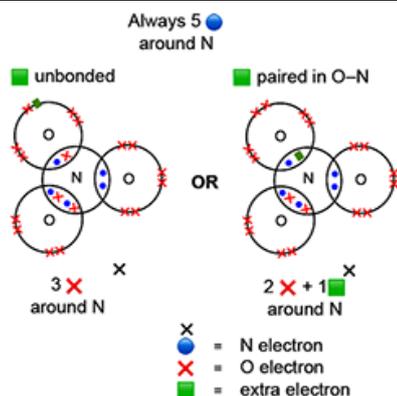
| | | | | |
|----|--|--|----------|---|
| | | | | net dipole moment: the molecule is non-polar |
| | | Total | 3 | |
| 10 | | <p>Level 3 (5–6 marks) Describe the types of structure and bonding of all four elements AND explains most of the differences in melting points in terms of the relative strengths of the forces between the particles.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3–4 marks) Attempt to describe the types of bonding of three elements AND explains most of the differences in melting points in terms of the relative strengths of the forces between the particles.</p> <p>OR Describe in detail and bonding of two of the three types of structure AND explains most of the differences in melting points in terms of the relative strengths of the forces between the particles.</p> <p><i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i></p> <p>Level 1 (1–2 marks) Attempt to describe the bonding of two elements AND explains most of the differences in melting points in terms of the relative strengths of the forces between the particles.</p> <p>OR Describes in detail the bonding of one of the three types of structure AND explains the melting point in terms of the strength of the forces between the particles.</p> <p><i>The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.</i></p> | 6 | <p>Indicative scientific points may include:</p> <p>ALLOW minor omissions as we are looking for a holistic approach to LoR marking.</p> <p>Al (Giant metallic)</p> <ul style="list-style-type: none"> • Giant metallic structure/lattice • Strong metallic bonding • Electrostatic attraction between (positive) metal ions/cations and delocalised electrons • A lot of energy needed to break bonds <p>Si (Giant covalent)</p> <ul style="list-style-type: none"> • Each Si atom forms 4 bonds / bonds with 4 other Si atoms • Giant covalent structure/lattice • Strong covalent bonds between atoms • Between shared pair of electrons and adjacent nuclei. • Most energy needed to break bonds <p>P, S (Simple covalent)</p> <ul style="list-style-type: none"> • <u>Simple</u> covalent / molecular structure/lattice • Strong covalent bonds between atoms • Weak induced dipole-dipole interactions between molecules* • Least energy to overcome the forces • Melting point of S₈ > P₄ |

| | | | |
|--|--|---|--|
| | | <p>0 mark <i>No response or no response worthy of credit.</i></p> | <ul style="list-style-type: none"> • More electrons • Stronger induced dipole-dipole interactions • DO NOT ALLOW breaks BONDS • IGNORE van der Waals' (VDW) <p>*ALLOW London (dispersion) forces for induced dipole-dipole interactions.</p> <p>Aspects of the communication statement might typically not have been met when irrelevant information (e.g. ionisation energies, ionic radius etc) have been included.</p> <p><u>Examiner's Comments</u></p> <p>Structure and bonding continue to be a difficult concept for many candidates. High-attaining candidates were able to identify why the element had a certain magnitude of melting point. They clearly linked the structure type with the type of bonding. They then described, in detail, the nature of the bond. The strength of force required to break/overcome the bond/London Force was linked to the melting point.</p> <p>It was very common for 'giant' to be omitted in the name of the lattice, especially in Al. Candidates find it particularly challenging to associate the correct terminology with the correct structure, often describing intermolecular forces in giant covalent explanations or use of molecules in giant metallic explanations. London forces were mentioned widely but sometimes not described as being forces between molecules and not linked to the increased number of electrons.</p> <p>A holistic, rather than a point</p> |
|--|--|---|--|

| | | | | | |
|----|--|--|--------------|----------|---|
| | | | | | <p>based, approach is used in marking these responses. This allowed Level 2 to be given when the candidate did not use all of the correct terminology throughout the three structure types.</p> <p>Several candidates described the varying melting point going across the period as being due to atoms having more electrons in the outer shell and a greater nuclear charge.</p> <p> OCR support</p> <p>Our bonding delivery guide provides details of common misconceptions students hold relating to this topic, and also includes resources and guidance that can help overcome them: Teach Cambridge (ocr.org.uk)</p> |
| | | | Total | 6 | |
| 11 | | | B | 1 | <p><u>Examiner's Comments</u></p> <p>The correct answer was B. Candidates generally understood that these anomalous properties were due to hydrogen bonding. A few selected C, associating the incorrect type of intermolecular force.</p> |
| | | | Total | 1 | |
| 12 | | | C | 1 | <p><u>Examiner's Comments</u></p> <p>The correct answer was C. This question was answered well, alongside Q2. Candidates should aim to separate explanations regarding chemical and physical properties. B was a common wrong answer and a few candidates suggested that the</p> |

| | | | | | |
|----|---|--|--|---|---|
| | | | | | covalent bonds need to be broken, selecting A. |
| | | | Total | 1 | |
| 13 | a | | <p>H–O–N</p> <p>104.5° ✓</p> <p>2 bonded pairs/regions AND 2 lone pairs (around O) AND lone pairs repel more ✓ <i>Independent of bond angle</i></p> <p>O–N–O</p> <p>120° ✓</p> <p>3 bonded regions/pairs (around N) ✓ <i>Independent of bond angle</i></p> | 4 (AO 1.2) (AO 2.1) (AO 1.2) (AO 2.1) | <p>Throughout,</p> <ul style="list-style-type: none"> • IGNORE names of shapes (even if wrong) • IGNORE 'electrons repel' • DO NOT ALLOW 'atoms repel' <p>-----</p> <p>---</p> <p>ALLOW 104–105°</p> <p>lp for lone pair (of electrons) ALLOW bp for bonding pair (of electrons) 'bond' for 'bonded pair'</p> <p>IGNORE electron density</p> <p>ALLOW 115–125°</p> <p>3 bonded areas / environments ALLOW 3 regions / areas of electron density 3 bonded groups</p> <p>ALLOW 2 bonded pairs and 1 double bond</p> <p>OR 2 bonded pairs and 1 bonded region</p> <p><u>Examiner's Comments</u></p> <p>This question required candidates to apply their knowledge and understanding of bond angles and electron pair repulsion in a novel context. The best candidates rose to this challenge, securing all four marks for correct bond angles and explanations in terms of the numbers of bonded and lone pairs.</p> |

| | | | | | |
|--|---|----|--|------------------------------------|--|
| | | | | | <p>The 104.5° and 120° were commonly seen and high scoring candidates provided excellent reasoning. The best explanation for 120° was in terms of three bonding regions and no lone pairs.</p> <p>Lower scoring responses often reasoned that bond angles are determined by lone pairs repelling the atoms, with the role of bonding pairs often being ignored.</p> |
| | b | i | <p>$\text{Al}_2\text{O}_3 + 6\text{HNO}_3 \rightarrow 2\text{Al}(\text{NO}_3)_3 + 3\text{H}_2\text{O}$</p> <p>Any THREE species correct ✓ Correct balanced equation ✓</p> <p>DO NOT ALLOW more than 4 species in equation</p> | <p>2 (AO 2.5) (AO 2.6)</p> | <p>ALLOW multiples</p> <p>IGNORE state symbols (even if wrong)</p> <p>ALLOW ionic equation</p> <p>$\text{Al}_2\text{O}_3 + 6\text{H}^+ \rightarrow 2\text{Al}^{3+} + 3\text{H}_2\text{O}$ Mark using same criteria</p> <p><u>Examiner's Comments</u></p> <p>Candidates were required to write a balanced equation for an acid–base reaction. As with Question 4 (b) (ii), candidates needed to write formulae from what should have been common ions, but the formulae for aluminium oxide and aluminium nitrate were often incorrect.</p> <p>In the equation, the reactants and products were sometimes unbalanced, or incorrectly balanced. A common error was H₂ instead of H₂O as the second product.</p> <p>The question was an excellent discriminator.</p> |
| | | ii | | <p>2 (AO 2.1) (AO 2.5)</p> | <p>NOT REQUIRED</p> <ul style="list-style-type: none"> • Charge ('-') • Brackets • Circles • N and O symbols |



1st mark: 8 Electrons around N as above
 1 single covalent bond,
 1 dative covalent bond
 1 double bond

2nd mark: 8 electrons around each O
AND 6 O electrons around each O

Only award 2nd mark if 1st mark awarded
NO ECFOR

IGNORE inner shells

ALLOW rotated diagram

In **N=O** bond, **ALLOW** sequence
 × × • •

ALLOW non-bonding electrons
 unpaired

ALLOW dot and cross labels
 swapped:

i.e. • for O electrons and × for N
 electrons

Examiner's Comments

Candidates were expected to use the displayed formula of nitric acid to identify that the central N atom had one double bond, one covalent bond and one dative covalent bond. This information then gave the strategy for the dot and cross diagram.

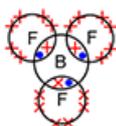
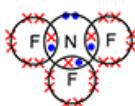
Although virtually all candidates attempted the dot and cross diagram, only about a quarter of candidates could be credited with a meaningful response. The key was to use nitrogen's 5 outer shell electrons and to combine these with 3 oxygen electrons or 2 oxygen electrons and the extra electron. Then the remaining oxygen electrons could be added, taking care that there were 6 around out O atom. Finally the extra electron would need to be placed in an octet gap.

Many candidates showed just 4 nitrogen electrons and this approach resulted in no marks. Other common errors included 3 double bonds around the N atom, and a lone pair on the N atom.

This dot and cross diagram discriminated between higher scoring candidates extremely well.

| | | | | | |
|----|---|--|--|---------------|--|
| | | | Total | 8 | |
| 14 | a | | <p>ALLOW upper case when it is obvious, e.g. ALLOW CR for Cr, AS for As</p> <p>ALLOW names for elements</p> <p>THREE from: N O F H ✓</p> | 1 (AO 1.1) | <p>DO NOT ALLOW ANY OTHER ELEMENTS (CON)</p> <p>Examiner's Comments</p> <p>Most candidates selected N, O and F, with other responses choosing other elements seemingly at random.</p> |
| | b | | P OR S ✓ | 1 (AO 1.1) | <p>ALLOW S₈, P₄</p> <p>ALLOW As, Se</p> <p>Examiner's Comments</p> <p>Candidates found this question harder than Questions 1 (a) and (b) with S and P being the most common correct elements seen. As and Se were also allowed. Si was a common incorrect response.</p> |
| | c | | S ✓ | 1 (AO 2.1) | <p>ALLOW SF₆</p> <p>Examiner's Comments</p> <p>The answer S was well known, with SF₆ being the specification example of a compound with octahedral molecules.</p> |
| | | | Total | 3 | |
| 15 | | | B | 1 (AO 1.2) | <p>Examiner's Comments</p> <p>The correct answer was B. Most candidates did not recognise that Si has covalent bonds between atoms so included it or did not recognise that water forms London forces as well as hydrogen bonds and therefore excluded it.</p> |
| | | | Total | 1 | |
| 16 | | | A | 1 (AO 1.1) | <p>Examiner's Comments</p> <p>Most candidates recognised HCN to be linear and therefore polar due to lack of symmetry – answer A. The most common error was D.</p> |
| | | | Total | 1 | |

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|----|---|----|--|--------------------|---|
| 17 | a | i | Shared pair of electrons ✓ | 1 (AO 1.1) | <p>IGNORE comments about attraction between nuclei and shared pair OR magnetic attraction</p> <p>Examiner's Comments</p> <p>Most candidates correctly described a covalent bond as a shared pair of electrons. Where this mark was dropped, it was usually because of the omission of 'pair' or 'shared', e.g. 'shared electrons'.</p> |
| | | ii | <p>NF₃: 3 'dot-and-cross' bonds AND 1 lone pair around N AND 3 lone pairs around each of the 3 F atoms ✓</p> <p>BF₃: 3 'dot-and-cross' bonds ONLY around B AND 3 lone pairs around each of the 3 F atoms ✓</p> | 2 (AO2.5 ×2) | <p>Use annotations with ticks, crosses ECF etc. for this part</p> <p>Must be 'dot-and-cross' using 2 different symbol for electron source ONLY</p> <p>IGNORE absence of circles</p> <p>ALLOW 1 mark for correct dot and cross diagrams for NF₃ AND BF₃ BUT with F lone pairs omitted</p> <p>ALLOW absent symbols from circles</p> <p>A lone pair can be shown as 2 single electrons</p> <p>IGNORE charges</p> <p>Examiner's Comments</p> <p>The 'dot-and-cross' diagrams were usually correct. Errors were commonly the result of missing a lone pair of electrons from one or more fluorine atoms.</p> <p>BF₃ was the more challenging diagram suggesting that some candidates were unfamiliar with molecules with less than an octet in their outer shell. Some candidates used two electrons from one of the fluorine atoms to show a double bond around the</p> |

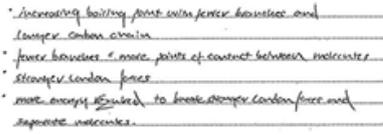


| | | | | | central B atom to complete the octet. | | | | | | | | |
|-----------------|------------|---|--------------------|--|---------------------------------------|-----------------|------|-----------|-----------------|------|-----------------|--------------------|--|
| b | i | <p>Bond angles and shapes</p> <table border="1"> <thead> <tr> <th></th> <th>Bond angle</th> <th>Name of shape</th> </tr> </thead> <tbody> <tr> <td>NF₃</td> <td>107°</td> <td>pyramidal</td> </tr> <tr> <td>BF₃</td> <td>120°</td> <td>trigonal planar</td> </tr> </tbody> </table> <p>ALL 4 points → 2 marks ✓✓ 2 OR 3 points → 1 mark ✓</p> | | Bond angle | Name of shape | NF ₃ | 107° | pyramidal | BF ₃ | 120° | trigonal planar | 2 (AO1.2 ×2) | <p>For NF₃ ALLOW 106–108° OR 109.5° – 2.5° ALLOW pyramid ALLOW trigonal pyramid(al)</p> <p>For BF₃ ALLOW planar triangle BUT 'planar' is insufficient</p> <p><u>Examiner's Comments</u></p> <p>This bond angles and shapes rewarded the well-prepared candidates, with many being given both available marks. The commonest error was NH₃ shown with a tetrahedral shape and a bond angle of 109.5°. This part discriminated very well.</p> |
| | Bond angle | Name of shape | | | | | | | | | | | |
| NF ₃ | 107° | pyramidal | | | | | | | | | | | |
| BF ₃ | 120° | trigonal planar | | | | | | | | | | | |
| | ii | <ul style="list-style-type: none"> NF₃ has 3 bonded pairs AND 1 lone pair (of electrons) AND lone pairs repel more (than bonded pairs) ✓ BF₃ has three bonded pairs (of electrons) ✓ | 2 (AO1.2 ×2) | <p>ALLOW lp for lone pair (of electrons) bp for bonding pair (of electrons) regions for electron pairs</p> <p>ALLOW 'bonds' for 'bonded pair'</p> <p>IGNORE 'electrons repel'</p> <p>DO NOT ALLOW 'atoms repel'</p> <p><u>Examiner's Comments</u></p> <p>Most students had the right idea here, but some lacked the detail for the marks. Some discussed repulsion in general terms, without referring the number of electron pairs. This question discriminated very well.</p> | | | | | | | | | |

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| | | | |  Misconception Many students can describe electron pair repulsion theory but many think that molecular shapes are determined by lone pairs, with bonded pairs often being ignored. Others seem to believe that lone pairs repel atoms. In this question, explanations sometimes claimed that NF_3 and BF_3 molecules have different shapes because a NF_3 molecule has a lone pair, resulting in no credit. |
| | | | Total | 7 |
| 18 | | <p><i>Each marking point is independent</i></p> <p>Chain length: interaction between molecules</p> <p>Chain length (in pentane) is longer AND more (surface) contact OR greater surface area/SA✓</p> <p>London forces: strength and energy</p> <p>Stronger / more London forces OR more energy to break London forces ✓</p> | <p>Comparisons needed throughout ORA throughout</p> <p>Assume the following for longer chain</p> <ul style="list-style-type: none"> • larger/bigger molecule • more C (and H) • more atoms • more electrons <p>BUT 'branching' is a CON</p> <p>IGNORE comments about packing</p> <p>ALLOW induced dipole(–dipole) interactions for London forces</p> <p>IGNORE van der Waals'/vdw forces</p> <p><u>Examiner's Comments</u></p> <p>Most candidates were given 1 or 2 marks, with some omitting the idea of surface area or surface contact. Most candidates identified London forces or induced dipole interactions as the relevant intermolecular force. A few candidates gave a general comment in terms of 'intermolecular' forces without specifying the type of intermolecular forces.</p> | <p>2 (AO1.1 ×2)</p> |

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| | | | | | There has been a general improvement in candidate responses to this type of question with fewer candidates than in previous exams suggesting the breaking of hydrogen bonds or covalent bonds. |
| | | | Total | 2 | |
| 19 | | | B | 1 (AO 1.1) | <u>Examiner's Comments</u> Almost all candidates selected the correct response of B. The main distractor proved to be D, the other type of dipole–dipole interaction. |
| | | | Total | 1 | |
| 20 | | | <p>Trend for all 3 hydrocarbons (1 mark): Boiling point increases with less branching OR less methyl/alkyl groups/side chains ✓</p> <p>Explanation with comparison (3 marks):</p> <p>Branching and surface contact (Less branching gives) more (surface) contact / interaction (between molecules) ✓</p> <p>Surface contact and London forces (More surface contact) gives more /stronger induced dipole(–dipole) interactions/ London forces ✓</p> <p>Energy and intermolecular forces More energy to break induced dipole(–dipole) interactions/ London forces/intermolecular forces/intermolecular bonds (with less branching) ✓</p> | 4 (AO1.1) (AO1.2 X3) | <p>ANNOTATE WITH TICKS AND CROSSES Comparisons needed throughout ORA throughout</p> <p>Must have link between rank order of branching and boiling point for all 3. ALLOW Hexane is least branched/straight chain and has highest bp AND 2,2-dimethylbutane is most branched and has lowest bp. IGNORE Chain length</p> <p>Surface area alone is not sufficient, must have idea of contact.</p> <p>DO NOT ALLOW arguments comparing different numbers of electrons (as all have the same number).</p> <p>IGNORE van der Waals'/vdW forces OR IDID OR IDD</p> <p>ALLOW 'more energy to break intermolecular forces' if intermolecular forces are not identified or incorrect. IGNORE harder to overcome/break intermolecular</p> |

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| | | | | <p>forces (no reference to energy) IGNORE just 'bonds' intermolecular/London forces required</p> <p><u>Examiner's Comments</u></p> <p>Most candidates attempted this question, gaining at least 1 mark, with over half scoring 3 or more marks. Responses often lacked clarity as many candidates struggled to articulate their ideas. It was common to see lengthy responses often with unnecessary repetition and sometimes even contradictions. A good strategy adopted by some was to draw skeletal formulae for the compounds next to the data provided. This enabled them to focus their response more easily on the extent of branching.</p> <p>Many candidates were unable to give a clear trend for the first marking point, as asked for in the question, but were able gain credit by a lengthier comparison of all three as indicated in the extra guidance. However, this mark was often lost through incomplete explanation, not referring to boiling point at all or an attempt to compare just chain length. The most common error for the second mark was omission of 'contact' or 'interaction' with reference only to surface area or 'packing' of molecules. Some lost this mark for a change in number of electrons. The third marking point was the most frequently awarded. Some candidates lost the mark for not explicitly naming the intermolecular forces as London forces/induced dipole-dipole interactions or for incorrectly using van der Waals. Some lost the mark for not explicitly indicating how increased or decreased contact would affect the strength or magnitude of London forces, e.g. 'less contact to form London</p> |
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| | | | | <p>forces'. The final mark was harder to obtain as it needed to be clear that energy was required to break intermolecular forces. For example, 'less energy to break bonds' or 'easier to separate the molecules' or 'more energy to boil' were not sufficient.</p> <p> Misconception</p> <p>Responses often highlighted that candidates lacked understanding about what London forces are, e.g. indicating that they form 'between atoms' or referring to induced dipole-dipole forces as something else. Intermolecular forces are difficult to fully comprehend as they can't be visualised making this a challenging topic to teach.</p> <p>OCR have produced a 'Bonding' teaching guide with lots of useful suggestions and resources. This includes a link to this Salters A Level chemistry revision activity on intermolecular bonding</p> <p>Exemplar 1</p>  <p>This exemplar shows a clear, concise response. The candidate has drawn skeletal structures next to the table. The trend is stated first followed by a detailed explanation, presented as a bullet point list, with all 4 marking points awarded.</p> | |
| | | | Total | 4 | |
| 21 | | A | | 1 (AO1.2) | <u>Examiner's Comments</u> |

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| | | <p>Si: no mobile/delocalised electrons OR no charge carriers OR no mobile ions</p> | <p>Most gained at least 1 mark, usually for recognising that for MgS to have a higher melting point that it must contain stronger bonds than in PCl_3. Responses highlighted a range of misconceptions including the presence of intermolecular forces in ionic/metallic substances, oppositely charged atoms in ionic compounds, and thinking London forces are between atoms. Most were able to gain the conductivity mark, but some compared to PCl_3 rather than Si as asked in the question. Some described 'mobile ions' in Al or that Si has 'no electrons'. The use of 'free electrons' was seen in many responses, and we would encourage the use of 'delocalised electrons' for a more accurate description of metallic bonding.</p> <p> OCR support</p> <p>OCR have produced a KS4-KS5 transition guide for bonding and structure to support teaching of these tricky concepts.</p> <p>A bonding delivery guide is also available.</p> <p> Assessment for learning</p> <p>Checking understanding of different types of bonding and structure plus links to their physical properties is very important. OCR have produced a range of multiple choice question quizzes that can be used to help check understanding - these are available as digital versions as well, enabling you to view responses. Guidance is given on how to use the digital versions on</p> |
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| | | | | | the OCR website. A useful multiple-choice quiz to use here is on electrons, bonding and structure.. |
| | | | Total | 8 | |
| 23 | i | Titanium (IV) oxide ✓ | | 1 (AO2.5) | <p>DO NOT ALLOW titanium dioxide</p> <p><u>Examiner's Comments</u></p> <p>Very few candidates gave the correct answer for this question. The most common errors included: titanium oxide, titanium(IV) dioxide, titanium oxide(IV), titanium(II) oxide. A few also attempted to give names like those for organic compounds: 1,1-titanium dioxide or the reverse 1,1-dioxytitanium.</p> <p>How Science Works</p> <p>It is important in Chemistry to have clear communication by use of systematic and unambiguous nomenclature. This includes the use of Roman numerals to indicate the magnitude of the oxidation number when an element, such as Ti, may have different oxidation numbers in different compounds. See specification statement 2.1.5(c) and HSW8.</p> |
| | ii | <p>FIRST CHECK ANSWER ON ANSWER LINE If answer = 2.67 kg award 4 marks</p> <p>-----</p> <p>$n(\text{Ti}) = \frac{1000}{47.9}$ OR 20.8768... (mol) ✓</p> <p>$n(\text{Na})$ for 72% yield = 20.88×4 OR 83.5073... (mol) ✓</p> <p>$n(\text{Na})$ for 100% yield = $83.51 \times \frac{100}{72}$ OR 115.98237... (mol) ✓</p> <p>mass Na = $115.98 \times 23.0 = 2667.659...$ (g) = 2.67 (kg) ✓</p> | | 4 (AO2.2 × 4) | <p>ALLOW ECF throughout TAKE CARE: values shown may be truncated calculator values.</p> <p>Steps can be calculated in any order which will change the intermediate answers. Marks are for the processing of the data.</p> <p>ALLOW 3SF up to calculated value throughout</p> <p>IGNORE rounding errors past 3SF</p> <p>Common Errors for 3 marks: 1.92 (missing yield) 1.38 (yield wrong way round) 0.673 (use of Mr 189.9 for TiCl₄)</p> |

3 SF AND kg
required

instead 47.9 for Ti)

Examiner's Comments

Candidates found this calculation quite challenging, with less than a quarter achieving full marks. The most common errors are highlighted on the mark scheme. Many that struggled were often given credit for the x4 ratio mark but only if it was possible to see this in the working. Many gave multiple, often contradictory attempts at the calculation. It was not always clear how the final answer had been obtained. Clear working enables us to follow the logic and give ECF where appropriate.

Many divided 1000 g by the molar mass for TiCl_4 and then found 72% of this. It was important here to read the question carefully to ensure complete understanding.

Exemplar 1

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

$$\text{actual yield} = \frac{\% \text{ yield}}{100} \times \text{theoretical yield}$$

$$\text{actual yield} = \frac{72}{100} \times 1000$$

$$\text{actual yield} = 720 \text{ g}$$

$$\text{mass of sodium} = \dots 0.167 \dots \text{ kg [4]}$$

This candidate achieved 3 out of the 4 possible marks. The steps in their calculation are logical and it is easy to follow their working and therefore spot the error in their calculation. They have divided by 4 rather than multiplying. It also shows the calculation can be performed in a different order to that on the mark scheme. All intermediate values are used in calculations as calculator values without rounding to ensure an accurate answer.

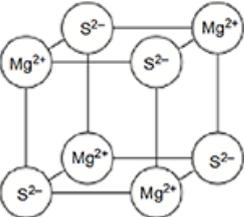
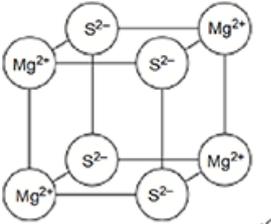
iii

Add water **AND** filter ✓

2
(AO 3.3
× 2)

ALLOW dissolve in water

| | | | | | |
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| | | | Ti does not dissolve OR NaCl does dissolve ✓ | | <p>ALLOW Ti is insoluble OR NaCl is soluble/aqueous</p> <p>ALLOW Ti is the residue OR NaCl is the filtrate</p> <p>Examiner's Comments</p> <p>Most candidates did not gain any credit here. However, the range of responses seen highlighted some misconceptions in their understanding of how different mixtures can be separated. Many assumed that sodium chloride was in solution/aqueous, not recognising that water was not present in this reaction. Responses such as "sodium chloride will evaporate" or "remove the water" were seen. Some gave a description of the purification method for an organic liquid - the use of a separating funnel and/or distillation were common. Some suggested the use of a magnet to remove Ti despite it being a non-magnetic metal.</p> <p> Misconception</p> <p>Understanding how to separate mixtures is covered in both KS3 and KS4 but it is important that these concepts can be applied during further study. Asking this type of problem solving question would make a good starter activity.</p> <p>Some useful activities for separating mixtures can be found in the GCSE Chemistry B (Twenty First Century Science) Chemical analysis transition guide</p> |
| | | | Total | 7 | |
| 24 | | i | (Electrostatic) attraction between oppositely charged OR + and - ions ✓ | 1 (AO1.1 ×1) | <p>Attraction is essential</p> <p>IGNORE references to metal and non-metal</p> |

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| | | | <p>Examiner's Comments</p> <p>Candidates answered this question well. Where candidates had not been given marks, it was usually because they omitted the term 'ions' or did not state that an ionic bond is between metals and non-metals.</p> |
| | ii |  <p>Mg²⁺ shown alternately in FOUR circles ✓</p> <p>S²⁻ shown alternately in FOUR circles ✓</p> | <p>ALLOW labels if seen outside circles provided it clear which circle the label applies to</p> <p>ALLOW 1 mark for Mg AND S shown alternately, each in FOUR circles</p> <p><i>i.e. with no charges or incorrect charges</i></p> <p>ALLOW 1 mark for 2+ / +2 AND 2- / -2 shown alternately in FOUR circles (with no Mg and S)</p> <p>DO NOT ALLOW All circles with same ion,</p> <p><i>i.e. all Mg²⁺ OR all S²⁻</i></p> <p>ALLOW 1 mark for 4 Mg²⁺ AND 4 S²⁻ but NOT shown alternately</p> <p>e.g.</p>  <p>Examiner's Comments</p> <p>Most candidates correctly drew alternating Mg²⁺ and S²⁻ labels in the circles. Some candidates made errors, however, including 2+ and 2- without Mg and S, incorrect or omitted charges, and</p> |

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| | | | | | placing the ions in layers rather than alternating. |
| | | | Total | 3 | |
| 25 | | | A | 1(AO1.1) | <u>Examiner's Comments</u> Most candidates knew the concept of electronegativity well and selected A as the correct response. |
| | | | Total | 1 | |
| 26 | | | D | 1(AO1.1) | <u>Examiner's Comments</u> This question was direct recall of specification content and most candidates selected D as the correct answer. |
| | | | Total | 1 | |
| 27 | | | A | 1(AO1.2) | <u>Examiner's Comments</u> This question was not well answered, with many candidates giving the other options rather than the correct answer of A. The candidates who were successful tended to draw out the shape of the molecules |
| | | | Total | 1 | |
| 28 | | | <p>CO₂ bond angle = 180° AND H₂O bond angle = 104.5° ✓</p> <p>CO₂ has 2 double bonds / 2 bonding regions ✓</p> <p>H₂O has 2 bonded pairs AND 2 lone pairs ✓</p> <p>Lone pairs repel more than bonding pairs ✓</p> | <p>4 (AO 1.1) (AO 2.1 × 3)</p> | <p>ALLOW 104–105 IGNORE Names of shapes even if incorrect</p> <p>ALLOW alternative phrases/words for repel e.g. 'push apart' DO NOT ALLOW atoms repel</p> <p><u>Examiner's Comments</u> Candidates continue to find understanding of shapes of molecules a very challenging topic to grasp. Very few were able to gain all 4 marks, with most gaining little or no marks. The most</p> |

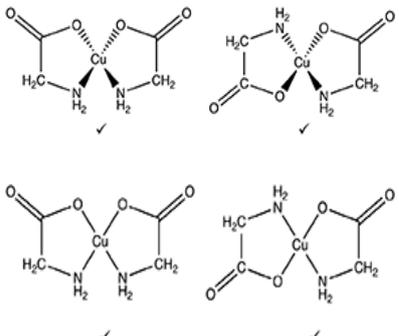
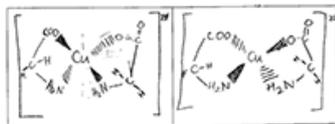
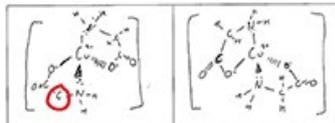
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| | | | | | <p>common mark given was for lone pairs repelling more than bonding pairs. Many only stated a lone pair decreases bond angle by 2.5° but did not explain that this was caused by increased repulsion.</p> <p>The most common error was stating that CO_2 has 2 bonding pairs – it doesn't, as it has 4 bonding pairs which are arranged as 2 double bonds. They could also state that it has 2 bonding regions. Lots stated CO_2 has no lone pairs and H_2O has 2 lone pairs but without reference to bonding pairs of electrons so lost out on 2 marks. In fact, it was fairly common that candidates indicated that only lone pairs cause repulsion, e.g. stating no repulsion in CO_2 "no lone pairs so there will be no repulsion". Though these two molecules are ones candidates will have prior knowledge of before A Level, a range of bond angles were suggested.</p> <p>The most successful candidates drew out dot cross diagrams and/or displayed formula to be able to count pairs of electrons around the central atom.</p> |
| | | | Total | 4 | |
| 29 | a | | Number of optical isomers = 4 ✓ | 1 (AO2.1) | <p><u>Examiner's Comments</u></p> <p>Most candidates added two asterisks to the diagram of vitamin C for the possible chiral centres. More successful responses usually realised that two chiral centres would give rise to $2^2 = 4$ optical isomers, with 2 optical isomers being the commonest error.</p> |
| | b | i | Hydrogen bonding AND Many OH/hydroxyl / hydroxy / alcohol ✓ | 1 (AO2.1) | <p>ALLOW 4 OH DO NOT ALLOW OH⁻</p> <p><u>Examiner's Comments</u></p> |

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| | | | | | <p>Most candidates realise that hydrogen bonds would be formed from the OH groups in vitamin C to water. Candidates are advised to read the question carefully as the word 'extremely' was a hint that 'many' OH groups would be needed in the explanation. The most successful responses quoted that hydrogen bonds would form between the 4 OH groups in vitamin C and water. Some candidates stated that O atoms in vitamin C would be involved. This was not given marks as not all O atoms in vitamin C are a part of OH groups and capable of hydrogen bonding.</p> |
| | | ii | $x = 15 \checkmark$ $y = 31 \checkmark$ | <p>1 (2 ×AO3.2)</p> | <p><u>Examiner's Comments</u></p> <p>More successful responses determined that $x = 15$ and $y = 31$.</p> <p>The key to success here was to subtract the formula of vitamin C from the formula of the ester and to add the formula of water: $C_{22}H_{38}O_7 - C_6H_8O_6 + H_2O \rightarrow C_{16}H_{32}O_2 \rightarrow C_{15}H_{31}COOH$.</p> <p>A significant number of candidates did obtain one of these values, with 15/16 and 29/30/32 being common incorrect answers. Omitting part(s) of sequence above would result in these incorrect numbers.</p> |
| | | Total | | 4 | |
| 30 | a | i | <p>Structure and bonding NH_3 is (simple) molecular/simple covalent/ /has intermolecular forces AND NH_4NO_3 is ionic ✓</p> <p>Comparison of strength Ionic bonds are stronger than intermolecular bonds / forces between molecules OR Ionic bonds need more energy to break than intermolecular bonds ✓</p> | <p>2 (2× AO1.1)</p> | <p>For intermolecular bonds/forces ALLOW hydrogen bonds OR London Forces/induced dipole forces/permanent dipole forces OR van der Waals' forces</p> <p>ALLOW NH_4NO_3 has molecular ions NH_4^+ and NO_3^- are molecular ions</p> <p>ORA</p> |

| | | | | |
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| | | | | <p>ALLOW: Intermolecular bonds are weak AND ionic bonds are strong ✓</p> <p><u>Examiner's Comments</u></p> <p>Candidates found the explanation difficult, and the responses showed some misconceptions. For example, many suggested that NH_3 and NH_4NO_3 both have hydrogen bonds. Those identifying that NH_4NO_3 has ionic bonding usually compared the greater strength of ionic bonding over intermolecular forces in NH_3. Unfortunately, many candidates described the ionic bonds as acting between molecules.</p> <p>This question proved to be one of the most difficult on the paper.</p> <p> Misconception</p> <p>A good understanding of structure and bonding continues to be difficult for candidates, demonstrated by many incorrect explanations for the different boiling points. This is a key misconception.</p> <p>Understanding could be improved by first considering the following.</p> <ul style="list-style-type: none">• What is the type of bonding?• What are particles in the structure? <p>Candidates need to be very careful when describing the two types of structure containing covalent bonds:</p> <ul style="list-style-type: none">• Simple molecular with strong covalent bonds within the molecules and weaker intermolecular |
|--|--|--|--|---|

| | | | | |
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| | | | | <p>bonds between the molecules in the structure</p> <p>Giant covalent with strong covalent bonds between the atoms in the structure.</p> <p>Exemplar 1</p> <p><i>NH₃ and NH₄NO₃ both have hydrogen bonding however NH₄NO₃ has many more H bonds due to size of compound. This means more energy is required to break bonds.</i></p> <p>Exemplar 1 is typical of many, suggesting that NH₄NO₃ has hydrogen bonding, which is either stronger than in NH₃, or that NH₄NO₃ has more hydrogen bonds. This response was given 0 marks.</p> |
| | | ii | <p>(NH₄⁺) nitrogen has oxidation number of -3 AND (NO₃⁻) nitrogen has oxidation number of +5 ✓</p> <p><i>i.e. nitrogens are -3 AND +5 gets the mark BOTH signs essential</i></p> | <p>1 (AO1.2)</p> <p>Statement that one student is correct is NOT required. <i>Implicit in answer</i> ALLOW 3- AND 5+</p> <p><u>Examiner's Comments</u></p> <p>Considering the large number of candidates describing NH₄NO₃ as molecular in Question 1 (a) (i), most candidates identified here that NH₄NO₃ contains NH₄⁺ and NO₃⁻ ions. Most then went on to show that the nitrogen atoms in the ions have different oxidation numbers: -3 and +5 respectively.</p> <p>Candidates were only given marks if both signs had been included and this was usually the case. -4 and +6 were common incorrect responses, presumably by ignoring the charges on the ions. Comparatively few candidates grouped the nitrogen atoms together and suggested that they had the same oxidation number.</p> |
| b | i | | <p>Bond angles H₂NCH₂COONa, bond angle = 107° AND HOOCCH₂NH₃Cl, bond angle = 109.5° ✓</p> <p>Number of electron pairs</p> | <p>3 (3 ×AO1.2)</p> <p>ALLOW 107 ± 0.5 ALLOW 109 OR 110°</p> |

| | | |
|--|---|--|
| | <p>Mark independently of angles</p> <p>In NaOH/107°, (NH₂ has) 3 bonded pairs / 3 bonds AND 1 lone pair ✓</p> <p>In HCl/109.5°, (NH₃⁺ has) 4 bonded pairs / 4 bonds ✓</p> | <p>ALLOW NH₂ has 4 pairs, one of which is a lone pair</p> <p>For bonded pairs/bonds ALLOW bonded groups, atoms, elements, regions Bonded essential</p> <p>IGNORE electron region OR electron density</p> <p>IGNORE NH₃ has no lone pairs</p> <p>IGNORE lone pairs repel more (than bonded pairs)</p> <p>IGNORE shapes, even if wrong</p> <p>ALLOW bp for bonded pair and lp for lone pair</p> <p><u>Examiner's Comments</u></p> <p>This question required candidates to apply their knowledge and understanding of bond angles and electron pair repulsion of NH₃ and NH₄⁺ to amino acid salts. The best candidates rose to this challenge and secured all 3 marks for correct bond angles and explanations in terms of the numbers of bonded and lone pairs around the N atoms.</p> <p>Overall, candidates found this question quite difficult. Many different bond angles were predicted, with 120° being the commonest incorrect H-N-H bond angle in H₂NCH₂COONa. The explanation for 120° was in terms of three bonding pairs and no lone pairs. 104.5° was also seen, presumably relating H₂N to H₂O. The 109.5° bond angle was correct more often, as was its explanation in terms of 4 bonding pairs.</p> <p>Many successful responses showed working on diagrams in which bonded and lone pairs had been included. This strategy will</p> |
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| | | | <p>have helped candidates in their conclusions.</p> |
| ii | | <p>Equation: $2 \text{H}_2\text{NCH}_2\text{COOH} + \text{Cu}(\text{CH}_3\text{COO})_2 \rightarrow \text{Cu}(\text{H}_2\text{NCH}_2\text{COO})_2 + 2 \text{CH}_3\text{COOH}$</p> <p>✓</p> <p>Structures</p>  <p>Ligands must be shown as bidentate rings</p> <p>IGNORE connectivity for NH_2 BUT connectivity must be to O of COO</p> | <p>ALLOW molecular formulae or mixture, e.g. $2\text{C}_2\text{H}_5\text{NO}_2 + \text{CuC}_4\text{H}_6\text{O}_4 \rightarrow \text{CuC}_4\text{H}_8\text{N}_2\text{O}_4 + 2\text{C}_2\text{H}_4\text{O}_2$</p> <p>IGNORE charges i.e. IGNORE wrong or missing charges in ionic compounds if formula is correct/ e.g. ALLOW $\text{Cu}(\text{CH}_3\text{COO}^-)_2$, $\text{Cu}^+(\text{CH}_3\text{COO}^-)_2$</p> <p>ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous</p> <p>IGNORE charges</p> <p>ALLOW arc to represent $-\text{CH}_2-$ between: C of $\text{C}=\text{O}$ and NH_2</p> <p>3 (AO2.6) (2 ×AO2.5)</p> <p>ALLOW 1 mark for 2 'correct' structures shown as tetrahedral e.g.</p>  <p>IGNORE missing Hs on C, e.g.</p>  <p>Examiner's Comments</p> <p>Candidates were asked to predict an unfamiliar equation from provided information and to draw structures of square planar complexes containing an amino acid. Candidates found the structures easier than the equation, with many drawing 3D structures with 2 out-wedges and</p> |

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| | | | | <p>2 in-wedges and attaching the NH₂ and COO groups correctly. It was also common to see a 'criss-cross' orientation, looking down on the complex, which is easier to draw. Many candidates connected the NH₂ and COO groups next to, and across from, each other in the isomers. A common error was for candidates to rotate their first structure, to produce a second drawing of the first structure. Less successful responses often tried to attach NH₂ and COO groups but with no CH₂ between the groups to produce a cyclic attachment. A minority of candidates ignored 'square planar' and drew tetrahedral structures instead.</p> <p>The equation proved to be very difficult, the commonest error being omission of the '2' balancing numbers for H₂NCH₂COOH and CH₃COOH. The formulae for ethanol or propanoic acid were also often seen for ethanoic acid.</p> <p>Candidates are advised to check all formulae and then to check balancing, the golden rules for successfully constructing all equations.</p> |
| | | Total | 9 | |