Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1		i	$C_{13}H_{19}N_3O_7$ ✓	1	**ALLOW** elements in formula in any order e.g. $C_{13}H_{19}O_7N_3$ **Examiner's Comments** Most candidates made a good attempt at working out the molecular formula of the structure as being $C_{13}H_{19}N_3O_7$. N and O were usually correct with mistakes most common with carbon (especially 12) and hydrogen (especially 17-20).
		ii	4 ✓	1	**Examiner's Comments** This question was answered well with the correct answer of 4 being seen on most scripts, reflecting good understanding of chiral carbon centres. The commonest incorrect response was 5, presumably by including the C atom on the bottom right of the structure within the -**C**H(CH_3)$_2$ group.
		iii	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF difference = 61.7, award 2 marks** -- M_r of **C** = 380 **OR** M_r of **D** = 441.7 ✓ Correct difference = 441.7 - 380 = **61.7** ✓ **AWARD** mark for **correct answer of 61.7 only**	2	**ALLOW** other approaches based on different atoms in **C** and **D**, e.g. Difference = 7 × (32.1 - 16) - 3 × (31 - 14) = 112.7 - 51 = **61.7** ✓ **Check answer from 2c(i) at top of response for ECF** **ALLOW ECF** from incorrect formula from **2c(i)** e.g. From $C_{12}H_{16}N_3O_6$ M_r of **C** = 349 **OR** M_r of **D** = 394.6 ✓ **ECF** difference = 394.6 - 349 = **45.6** ✓ **ECF** **Examiner's Comments** This question was answered

					extremely well with about three-quarters of candidates securing both marks. Most candidates calculated the molecular masses of compounds **C** and **D** as 380 and 441.7 respectively, to obtain a difference of 61.7. Some candidates adopted a simpler different approach which gives the same correct answer, working out the difference between the masses of nitrogen and phosphorus (for **C**) and oxygen and sulfur (for **D**). ECF was applied to any incorrect molecular formulae from Question 2 (c) (i) from which both marks could be obtained
			Total	**4**	
2			**IF** answer on answer line = 73518 **AWARD** 3 marks **IF** answer on answer line = 73500 **AWARD** 2 marks --- M_r of amino acid = 165 ✓ M_r of 500 molecules = 500 × 165 = 82500 ✓ M_r of polymer = 82500 – (499 × 18) = 73518 ✓ *(final answer must be given to nearest whole number)*	3	**ALLOW ECF** from incorrect M_r of amino acid **Alternative method:** Mr of repeat unit = 147 ✓ 147 x 500 = 73500 ✓ 73500 + 18 = 73518 ✓ **Common error for 2 marks** 36518 Use of Mr 91 82500 Not shown 165 in working **Common error for 1 mark** 45500 Use of Mr 91 **<u>Examiner's Comments</u>** Most candidates managed to score at least one mark here, either for correctly determining the molar mass of the monomer, the repeat unit in the polymer or alternatively they multiplied a molar mass by500. Many candidates gained 2 marks for either 73500 or 82500 but then struggled to account for thewater lost. Some candidates lost marks due to errors in calculating the molar mass of the monomer or some tried toincorporate the use of Avogadro's constant into the calculation. Many

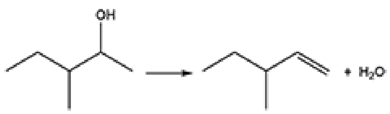
					misunderstood what atoms wouldbe lost during polymerisation. For example, a common incorrect response seen was found by subtracting2 from the correct molar mass giving 163, followed by multiplication by 500 to give 81500 and finallyadding of 2 to give 81502. Some struggled to understand what was meant by nearest whole number,e.g. rounding 73518 to 74000 or 82500 to 80000.
			Total	**3**	
3			**C**	1	**ALLOW** 1.5(0) **<u>Examiner's Comments</u>** Around two thirds of candidates gave the correct answer C, 1.50 mol dm^{-3} . Those that showed working were more likely to have the correct answer. Some only found the moles of ethylamine from the mass and M_r give so gave 0.03, A. Some candidates struggled to figure out that HC*l* was in excess, so used 0.04 moles of HC*l* to give a concentration of 2.0 mol dm^{-3}, D.
			Total	**1**	
4			**FIRST CHECK ANSWER ON THE ANSWER LINE** **IF answer = 54.63 (to 2 DP) award 2 marks** $\frac{(54 \times 78.54) + (56 \times 8.88) + (57 \times 5.10) + (58 \times 7.48)}{100}$ **OR** 54.6298 **OR** 54.630 ✓ = 54.63 (to 2 DP) ✓	2	**For 1 mark: ALLOW ECF** → to 2 DP if: • %s used with wrong isotopes **ONCE** **OR** • transposed decimal places for **ONE** % **<u>Examiner's Comments</u>** Candidates answered this question very well. A few mis-wrote the numbers and even fewer gave responses to the incorrect number of decimal places. This type of question has featured on previous examinations, and it was

					encouraging to see how well it was answered, even with more isotopes being included than previously.
			Total	**2**	
5			**C**	1	**Examiner's Comments** Most candidates recognised the correct atomic structure, a basic chemical skill taken forward from GCSE.
			Total	**1**	
6		i	Be: $1s^22s^2$ F: $1s^22s^22p^5$ ✓ Mg: $1s^22s^22p^63s^2$ C*l*: $1s^22s^22p^63s^23p^5$ ✓ Block: s p ✓	3	**1 mark** per correct row **ALLOW** upper case letter S and P, and subscripts, e.g. $2S_22P_5$ **IGNORE** superscripts/numbers given on block (e.g. s^2 and p^5) if the letter is clear **Examiner's Comments** A very well answered question with most candidates very confident in giving the correct electron configurations and blocks. Errors were rare but included: $2p^5$ or $3p^6$ ending for Cl; using mass number for number of electrons; and assigning group 17 as d block and giving orbital box diagrams rather than block.
6		ii	Across period 2, the (2)s subshell fills first, followed by the (2)p ✓ **same pattern or trend** of filling (the subshells) repeated in other periods ✓	2	**ALLOW** Elements in the same group have same number of electrons in their outer shells or subshell e.g. s^2 in group 2/ s^2p^5 in group 17(7) **ALLOW** Elements in the same period have the same number of energy levels/shells **ALLOW** for both marks for indication that the pattern repeats across each period e.g Across each period, elements repeat the pattern of electrons filling the s-subshell then p-subshell ✓ ✓ **Examiner's Comments**

					Many found this question challenging despite doing well in Question 2(a)(i). The question states 'use your answers from (a)(i)' but not many candidates wrote about the electron configurations they had given. Many gave very simplistic responses in terms of the number of electrons increasing but made no reference to how those electrons are arranged (e.g. 'number of electrons increases across a period as the electron configuration gets higher' or 'atomic number increases'). Some candidates struggled with terminology, often referring to 'block' or 'orbital' instead of subshell (e.g. 'outer electrons are in same block', 'going across a period the number of orbitals increases', 'elements in same group have their highest energy electron in same block' or 'orbital'). Candidates need clarity on the terminology used for electron configurations and periodic table i.e. blocks, shells, sub-shells and orbitals. It was rare for candidates to score both marks as this was a question that they were unfamiliar with. However, some did gain a mark for linking the number of outer shell electrons to the group number or stating that elements in the same period have the same number of shells. It was not enough to refer to the highest energy electron being in the s-subshell or p-subshell as this is the link to the block, but all groups in same block will be the same. Some described the trend in other physical or chemical properties. Some examples included: 'Elements have same chemical and physical properties due to similar electronic configuration'; 'as you go across period, number of electrons increase and their boiling and melting points increase'; and 'electrons are more

					easily lost in a paired orbital, due to greater repulsion and so have lower ionisation energies'. **OCR support** We have produced a transition guide on the topic of atomic structure. It covers content from KS4 and how this is developed at KS5 with a wide range of suggested resources to support teaching. At KS4, candidates are expected to be able to explain how the position of an element in the Periodic Table is related to the arrangement of electrons in its atoms, with development at KS5 to arrangement in to s, p and d orbitals. https:/ocr.org.uk/Images/170375-atomic-structure-ks4-ks5.pdf
		iii	Mg loses (2) electrons **AND** Cl gains an electron ✓ To gain a full/complete shell **OR** Noble gas configuration **OR** Stable/full octet✓	2	**ALLOW** Mg is oxidised **AND** Cl is reduced **<u>Examiner's Comments</u>** Generally, this question was well answered with a clear understanding of how and why ions are formed. However, approximately a quarter of students only gained 1 mark as they either didn't explain electrons being lost by Mg and gained by Cl or gave no justification. A common slip was stating Cl has one electron in its outer shell. Some described bonding between Mg and Cl, which wasn't what the question asked, but this didn't prevent them from scoring both marks.
		iv	$2Mg + O_2 \rightarrow 2MgO$ ✓	1	**ALLOW** multiples e.g. $Mg + \frac{1}{2}O_2 \rightarrow MgO$ **IGNORE** state symbols even if wrong

					Examiner's Comments Many candidates correctly gave the balanced equation here. However, some didn't balance but had the correct formula. A few gave Mg_2 as a reactant or MgO_2 as a product. Some had O_2 on both sides of the equation.
			Total	**8**	
7		i	Au + **4** HC*l* → **4** H^+ + AuCl_4^- + **3** e^- ✓	1 (AO 1.2)	**Examiner's Comments** Most candidates added '4' before HC*l* and H^+, and 3 before e^- to gain this mark. Where an error was made, it invariably was with the number of electrons, usually 4e^-.
		ii	**Formulae** **X** = NO ✓ **Z** = H2O ✓ **Equation Independent from ID of X and Z** HNO_3 + **3** H^+ + **3** e^- → NO + **2** H_2O **OR** NO_3^- + **4** H^+ + **3** e^- → NO + **2** H_2O ✓ **CHECK BELOW ANSWER SPACE FOR RESPONSE**	3 (AO 3.1 ×3)	If **X** and **Z** in wrong order award 1 out of 2 formula marks i.e. **X** = H_2O and **Z** = NO 1 mark **ALLOW** multiples **Examiner's Comments** Almost all candidates identified **X** and **Y** as NO and H_2O respectively, but the equation proved to be much more testing. Some candidates were careless, showing NO and H_2O the wrong way round (credited with 1 out of these 2 marks) or with charges. For the equation, candidates needed to consider the oxidation number change of N from +5 to +2, This should have naturally led to 3e^- being added on the left-hand side. Many candidates omitted the electrons entirely. Some did add 3e^- but on the right. This suggests that candidates would benefit with practising the construction of half equations.
			Total	**4**	

8		i	3-methylpentan-2-ol ✓	1 (AO 2.1)	**IGNORE** lack of hyphens or addition of commas **ALLOW** 3-methylpentane-2-ol **DO NOT ALLOW** 2-methylpentan-3-ol 3-methylpent-2-ol 3-methpentan-2-ol 3-methypentan-2-ol 3-methlypentan-2-ol **Examiner's Comments** A significant number of candidates lost the mark for missing -an- in their answer i.e. 3-methylpent-2-ol. Others lost the mark for incorrect spelling of methyl.
8		ii	 Correct structure of organic product ✓ Balanced equation ✓	2 (AO 2.7 × 2)	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **DO NOT ALLOW** additional reactants such as H^+ or [O] in the equation. **ALLOW** incorrect isomer 3-methylpent-2-ene for balancing mark. **Examiner's Comments** Most candidates did not score either mark here, despite the structures for B and C being given in the table below for (iii). Many thought this was oxidation, showing [O] in equations and giving a carbonyl product. Many had alkenes but still with the -OH present. Some attempted to use structural or displayed formulae but errors were made in giving the correct number of H atoms. For those that did have the correct structure, they often did not give an equation, added the acid as a reactant , or missed off the water as a product.

		iii	Priority groups on same side ✓ High(est) priority groups are CH_3CH_2 and CH_3 **OR** Low(est) priority groups are CH_3 and H ✓	2 (AO 3.1 × 2)	**ALLOW** suitable alternatives to 'priority' e.g. Groups with highest atomic number or more important groups etc. **ALLOW** priority groups are both on the top **IGNORE** references to relative mass of groups, Ar, Mr, **ALLOW** identification by name e.g. ethyl and methyl, or by circling on the structure. **IF** 'priority' is not mentioned **ALLOW** 1 mark for CH_3CH_2 and CH_3 are on same side **OR** H and CH_3 are on same side **Examiner's Comments** Many responses made no reference to 'priority' and/or discussed alkene C, suggesting that they didn't read the question fully. Candidates often struggled to find the right language to express themselves, such as reference to 'functional groups' or 'molecules' rather than priority groups. Lots discussed using *Mr* to assign priority with only a few stating correctly that it is atomic number that is used for CIP rules. Many, despite stating that priority groups are on the same side, didn't identify these groups so didn't get the second mark.
			Total	**5**	
9		i	**FIRST CHECK ANSWER ON ANSWER LINE** **If answer = 47.92 (to 2 DP) seen award 2 marks** (46 x 8.3) + (47 x 7.4) + (48 x 73.7) + (49 x 5.4) + (50 x 5.2) **OR** 381.8 + 347.8 + 3537.6 + 246.6 + 260 **OR** 4791.8 ✓	2 (AO 2.2) (AO 1.1)	**ALLOW** one mark for **ECF** from **seen** incorrect sum provided final answer between 46 and 50 and to 2 **DP** **Examiner's Comments** Most candidates scored both marks. Some lost marks for minor slips such as not giving their final answer to 2 decimal places or making calculator

<table>
<tr><td></td><td></td><td></td><td>4791.8/100
= 47.92 ✓ **2DP required**</td><td></td><td>errors. A few didn't know how to attempt the calculation or calculated the average mass.</td></tr>
<tr><td></td><td></td><td>ii</td><td>$(1s^2)2s^22p^63s^23p^63d^24s^2$ ✓

Look carefully at $(1s^2)$ $2s^22p^63s^23p^6$ – there may be a mistake</td><td>1
(AO1.1)</td><td>**ALLOW** subscripts

ALLOW 4s before 3d i.e. $(1s^2)2s^22p^63s^23p^64s^23d^2$

ALLOW upper case D, etc and subscripts, e.g. ……$3S_23P^6$

DO NOT ALLOW [Ar] as shorthand for $1s^22s^22p^63s^23p^6$

Examiner's Comments

Again, most scored this mark. Common errors included using the mass number for number of electrons, no 4s but $3d^4$ instead, 4d rather than 3d, $4p^2$ instead of $3d^2$ or filling up d orbital $3d^{10}$.</td></tr>
<tr><td></td><td></td><td>iii</td><td><table><tr><td></td><td>Protons</td><td>Neutrons</td><td>Electrons</td></tr><tr><td>$^{48}Ti^{2+}$</td><td>22</td><td>26</td><td>20</td></tr></table> ✓

ALL 3 numbers required for the mark</td><td>1
(AO2.1)</td><td>**Examiner's Comments**

Most candidates gained this mark. Common errors included giving 24 or 22 for number of electrons, or 48 or 24 for neutrons. A few used the relative atomic mass of 47.9 from the periodic table so gave 24.7 for number of neutrons.

Assessment for learning

Fractional numbers of subatomic particles are not possible. Candidates should be aware that the relative atomic mass is the weighted average of the masses of all of an element's isotopes, and the mass number of an isotope must be used to determine the number of protons and neutrons in the nucleus.</td></tr>
<tr><td></td><td></td><td></td><td>**Total**</td><td>**4**</td><td></td></tr>
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<table>
<tr>
<td>10</td>
<td>a</td>
<td></td>
<td>FIRST CHECK ANSWER ON THE ANSWER LINE 2

IF answer = 190.47 (to 2 DP) award 2 marks

$\frac{(188 \times 12.13) + (189 \times 16.75) + (190 \times 27.23) + (192 \times 43.89)}{100}$

OR 190.4677 OR 190.468 ✓

= 190.47 (to 2 DP) ✓</td>
<td>2
(AO1.2 ×2)</td>
<td>For 1 mark: ALLOW ECF → to 2 DP if:

• %s used with wrong isotopes ONCE
OR
• transposed decimal places for ONE %

<u>Examiner's Comments</u>

Candidates answered this question very successfully. Few candidates mis-wrote the numbers and even fewer gave answers to the incorrect number of decimal places. This type of question has featured on previous examinations and it was pleasing to see how well it was answered, even with more isotopes being included than in previous instances.</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td></td>
<td><table><tr><th>Element</th><th>Mass number</th><th>Protons</th><th>Neutrons</th><th>Electrons</th><th>Charge</th><th></th></tr><tr><td>Ni</td><td>62</td><td>28</td><td>34</td><td>$1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$</td><td>0</td><td>✓</td></tr><tr><td>P</td><td>33</td><td>15</td><td>18</td><td>$1s^2 2s^2 2p^6 3s^2 3p^6$</td><td>3–</td><td>✓</td></tr></table>Mark by row</td>
<td>2
(AO1.2 ×2)</td>
<td>Easiest to check element first
ALLOW P^{3-} ALLOW names for elements
IGNORE charges with element in 1st column, even if wrong.
For electron configuration, ALLOW $4s^2$ before $3d^8$ i.e. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$
ALLOW upper case D, etc and subscripts, e.g. ......$4S_2 3D_1$
ALLOW [Ar)$3d^8 4s^2$

<u>Examiner's Comments</u>

This question produced many mixed responses. Most candidates correctly identified nickel. However, its electron configuration was frequently shown as $3d^{10}$ instead of $3d^8$ and some less successful responses gave nickel's relative atomic mass of 58.7 from the periodic table, instead of the mass number of the isotope provided. Many candidates selected the incorrect element for phosphorus, with argon being a key distractor from the extra 3 electrons in the P^{3-} ion. The numbers of protons and neutrons were largely correct,</td>
</tr>
</table>

					although the wrong way round for many less successful responses.
			Total	**4**	
11		i	Cu: 66% **AND** Zn 34% ✓	1 (AO2.6)	**<u>Examiner's Comments</u>** Question 1 (b) presented candidates with a mass spectrum of two elements in an alloy. This novel question was answered well, and the introductory part (i) provided candidates with a hint of how to approach the harder part (ii). Almost all candidates analysed the percentages to show that the brass sample contains 66% Cu and 34% Zn, the 34 being required in Question 1 (b) (ii).
		ii	**FIRST CHECK ANSWER ON THE ANSWER LINE** **If answer = 65.42 (to 2 DP) award 2 marks** --- **Numerator from Zn isotopes** (64 × 16.82) + (66 × 9.53) + (67 × 1.38) + (68 × 6.27) **OR** 2224.28 ✓ **Relative atomic mass** Numerator ÷ 34 **AND** answer to 2 DP ✓ *Mark **ECF** from numerator* $\frac{(64 \times 16.82) + (66 \times 9.53) + (67 \times 1.38) + (68 \times 6.27)}{34}$ ✓ = 65.42 (to 2 DP) ✓	2 (2 ×AO1.2)	**Refer to answer to 1b(i) for ECF from incorrect % composition of Zn and Cu** **ECF** ÷ by Zn % in **b(i)** --- **Common errors** 22.24 ÷100 and answer to 2 DP → *1 mark for numerator* 64.23 All 6 isotopes used → No marks 188.91 All 6 isotopes used → 6423 for numerator ÷34 and 2 DP → 1 mark by ECF **<u>Examiner's Comments</u>** Most candidates produced a stock expression for a relative atomic mass calculation with the numerator comprising the four zinc isotopes with their respective percentage abundances, equating to 2224.28. The second mark required candidates to realise that the numerator needed to be divided by the total zinc percentage abundance of 34% to produce a value of 65.42. Less successful responses divided by 100% to obtain a value of 22.24. Almost all candidates gave their

					answers to the required two decimal places. The second mark proved to be a very good discriminator, with some candidates usually obtaining both marks with less successful responses still able to obtain the first mark for the numerator.
			Total	**3**	