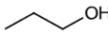
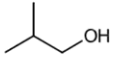


1(a)	The mass of a molecule OR the (weighted) average / (weighted) mean mass of the molecules	1
	Relative / compared to $\frac{1}{12}$ (the mass) of <u>an atom</u> of carbon-12 OR on a scale in which a carbon-12 atom / isotope has a mass of (exactly) 12 (units)	1
1(b)(i)	3	1
1(b)(ii)	8	1
1(b)(iii)	$\text{C}_3\text{H}_8\text{O} + 4\frac{1}{2}\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$	1
1(b)(iv)	 OH AND propan-2-ol / 2-propanol	1
	 OH AND propan-1-ol / 1-propanol	1
	Alternative answers (any two):  OH AND butan-1-ol / 1-butanol	
	 OH AND butan-2-ol / 2-butanol	
	 OH AND (2-)methylpropan-1-ol / (2-)methyl-1-propanol	
	 OH AND (2-)methylpropan-2-ol / (2-)methyl-2-propanol	

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Question	Answer	Marks
1(b)(v)	correct conversions of data to SI/consistent units $p = 100\,000$; $V = 20 \times 10^{-6}$; $T = 393$	1
	calculation of n ($= pV/RT$) from M1 values $n = \frac{100 \times 10^3 \times 20 \times 10^{-6}}{8.31 \times 393}$	1
	calculation of mass m ($= n \times Mr$) AND answer correct to 3sf $m = 6.12 \times 10^{-4} \times 60 = 0.0367$ (g)	1
	Alternative answer for using $\text{C}_4\text{H}_{10}\text{O}$: $m = 6.12 \times 10^{-4} \times 74 = 0.0453$ (g)	
	Total:	10

Question	Answer	Marks
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May/June 2017 9701/21 · Q1 (a), (b)(i), (b)(ii), (b)(iii), (b)(iv), (b)(v)

1(b)(i)	EITHER mass of an atom / isotope relative / compared to 1/12 (the mass) of (an atom of) C-12 OR on a scale in which a C-12 (atom / isotope) has (a mass of exactly) 12 (units) OR mass of one mol (of atoms) of an isotope relative / compared to 1/12 (the mass) of 1 mol of C-12 OR on a scale in which one mol C-12 (atom / isotope) has a mass of (exactly) 12 g	2 1 1
1(b)(ii)	$\frac{(10.0129 \times 19.78) + (80.22x)}{100} = 10.8$ $x = 10.9941$	1 1
Total:		6

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Question	Answer	Marks
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May/June 2017 9701/22 · Q1 (b)(i), (b)(ii)

1(b)(iii)	molecular = C ₈ H ₈	1
	empirical = CH ₂	1
	using alternative supplied data molecular = C ₆ H ₁₂	
	empirical = CH ₂	

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Question	Answer	Marks
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May/June 2017 9701/23 · Q1 (b)(iii)

2(d)(iii)	$4 \times 10^{-4} / 0.0004$	1
2(d)(iv)	$2 \times 10^{-3} / 0.002$	1
2(d)(v)	392	1

May/June 2018 9701/22 · Q2 (d)(iii), (d)(iv), (d)(v)

4(e)(i)	M1 is for the process of taking the % of each element and dividing by its relative atomic mass. <table><tr><td>C</td><td>H</td><td>N</td><td>O</td></tr><tr><td>$\frac{51.3}{12}$</td><td>$\frac{9.40}{1}$</td><td>$\frac{12.0}{14}$</td><td>$\frac{27.3}{16}$</td></tr></table> OR <table><tr><td>4.28</td><td>9.40</td><td>0.857</td><td>1.71</td></tr></table> M2 is for dividing the smallest %/A_r into each of the remaining values to produce the correct ratio. <table><tr><td>$\frac{4.28}{0.857}$</td><td>$\frac{9.40}{0.857}$</td><td>$\frac{0.857}{0.857}$</td><td>$\frac{1.71}{0.857}$</td></tr></table> OR <table><tr><td>4.9942</td><td>:</td><td>10.9685</td><td>:</td><td>1</td><td>:</td><td>1.9953</td></tr></table>	C	H	N	O	$\frac{51.3}{12}$	$\frac{9.40}{1}$	$\frac{12.0}{14}$	$\frac{27.3}{16}$	4.28	9.40	0.857	1.71	$\frac{4.28}{0.857}$	$\frac{9.40}{0.857}$	$\frac{0.857}{0.857}$	$\frac{1.71}{0.857}$	4.9942	:	10.9685	:	1	:	1.9953	2
C	H	N	O																						
$\frac{51.3}{12}$	$\frac{9.40}{1}$	$\frac{12.0}{14}$	$\frac{27.3}{16}$																						
4.28	9.40	0.857	1.71																						
$\frac{4.28}{0.857}$	$\frac{9.40}{0.857}$	$\frac{0.857}{0.857}$	$\frac{1.71}{0.857}$																						
4.9942	:	10.9685	:	1	:	1.9953																			
4(e)(ii)	C ₅ H ₁₁ NO ₂ AND because the EFM = RFM	1																							

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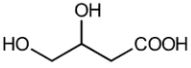
May/June 2018 9701/22 · Q4 (e)(i), (e)(ii)

2(d)(i)	$pV = nRT \therefore n = \frac{pV}{RT} = \frac{101\,325 \times 0.001}{8.31 \times 273} = 0.0447 \text{ mol}$ $\therefore M_r = \frac{m}{n} = \frac{4.13}{0.0447} = 92.4 \text{ or } 92.5$ M1 Use of $T = 273 \text{ K}$, $V = 0.001 \text{ m}^3$ and $p = 101325 \text{ Pa}$ M2 correct use of $pV = nRT$ using values from M1 M3 correct calculation of M_r using $4.13 \div$ moles from M2	3
2(d)(ii)	ClF ₃	1

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March 2019 9701/22 · Q2 (d)(i), (d)(ii)

Question	Answer	Marks
4(c)(iv)	 M1 hydrolysed nitrile on straight-chain 4C backbone M2 3,4-diol	2

March 2019 9701/22 · Q4 (c)(iv)

4(c)(i)	C ₃ H ₇ ClO ₂	1
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May/June 2019 9701/21 · Q4 (c)(i)

1(c)(ii)	concentration of butane = 0.3 mol dm^{-3} AND concentration of methylpropane = 0.7 mol dm^{-3}	1
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May/June 2019 9701/22 · Q1 (c)(ii)

4(c)	method 1	method 2	
M1	$1 / 28 (= 0.035714)$	$1 : 88 / 28 (= 3.14286)$	1
M2	$2 \times M1 (= 1 / 14 = 0.07143)$	$M1 / 44 (= 0.071429)$	1
M3	$M2 \times 24 = 1.7 \text{ dm}^3$	$M2 \times 24 = 1.7 \text{ dm}^3$	1

May/June 2019 9701/22 · Q4 (c)

1(b)	M1 $x / 100 \times 32 + (100 - x / 100 \times 34) = 32.09$	3
	M2 $(32x + 3400 - 34x) = 3209$ so $x = 95.5$	
	M3 S^{32} 95.5% AND S^{34} 4.5%	

May/June 2019 9701/23 · Q1 (b)

6(a)(i)	Orange / brown to colourless / decolourises	1
6(a)(ii)	any non-ambiguous structures of:	
	X $(\text{CH}_3)_2\text{C} = \text{CH}_2 / (\text{CH}_3)_2\text{CCH}_2$	1
	Y $\text{CH}_3\text{CH}_2\text{CH} = \text{CH}_2 / \text{C}_2\text{H}_5\text{CHCH}_2$	1
	Z $\text{CH}_3\text{CH} = \text{CHCH}_3 / \text{CH}_3\text{CHCHCH}_3$	1
6(a)(iii)	C_4H_8	1
6(b)(ii)	$\text{CH}_3(\text{CH}_2)_2\text{CH}_2\text{OH} + \text{Na} \rightarrow \text{CH}_3(\text{CH}_2)_2\text{CH}_2\text{ONa} + \frac{1}{2} \text{H}_2$	1
6(b)(iii)	M1 Reagent $\text{H}^+ / \text{Cr}_2\text{O}_7^{2-}$ M2 Observations for V orange to green M3 Observations for W no change / remains orange	3

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May/June 2019 9701/23 · Q6 (a)(i), (a)(ii), (a)(iii), (b)(i), (b)(ii), (b)(iii)

3(a)(i)	cracking	1
3(a)(ii)	enthalpy change of combustion / ΔH_c is high / large energy release (per mole / per unit mass) OR combust / burn easily	1
3(a)(iv)	M1 : infrared spectroscopy M2 : Compare / measure (characteristic) wavelengths	2
3(b)(i)	$\text{C}_4\text{H}_4\text{S(l)} + 6\text{O}_2\text{(g)} \rightarrow 4\text{CO}_2\text{(g)} + 2\text{H}_2\text{O(l)} + \text{SO}_2\text{(g)}$ • correct species • balancing • state symbols Award one mark for two correct bullet points, award two marks for all three correct.	2

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Question	Answer	Marks
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Oct/Nov 2019 9701/21 · Q3 (a)(i), (a)(ii), (a)(iv), (b)(i)

1(a)(ii)	the relative abundance / % abundance of (each) the isotopes.	1
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May/June 2020 9701/21 · Q1 (a)(ii)

5(d)(i)	Two structures representing the intermediate M1 $C_2H_5C^+HCH_3$ M2 $CH_3CH_2CH_2C^+H_2$	2
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May/June 2020 9701/21 · Q5 (d)(i)

1(a)	EITHER M1 (weighted) average/mean mass of the isotope(s)/an atom(s) M2 relative to 1/12 of the mass (of an atom) of ^{12}C (where an atom of ^{12}C is exactly 12). OR M1 mass of one mol of atoms M2 relative / compared to 1/12 (the mass) of 1 mol of C-12 OR in which one mol C-12 (atom) has a mass of (exactly) 12 g	2
1(b)	M1 $60.11/100 \times 69 + 39.89/100 \times 71$ M2 69.80	2
1(e)(ii)	M1 Identity of correct gallium containing product $NaGa(OH)_4$ OR $NaGaO_2$ M2 correctly balanced equation for reaction of Ga_2O_3 with $NaOH(aq)$ EITHER $Ga_2O_3 + 2NaOH + 3H_2O \rightarrow 2NaGa(OH)_4$ OR $Ga_2O_3 + 2NaOH \rightarrow 2NaGaO_2 + H_2O$	2

Question	Answer	Marks
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May/June 2020 9701/22 · Q1 (a), (b), (e)(ii)

2(a)	EITHER M1 mass of an atom / isotope M2 relative / compared to 1/12 (the mass) of (an atom of) C-12 OR on a scale in which a C-12 (atom / isotope) has (a mass of exactly) 12 (units) OR M1 mass of one mol (of atoms) of an isotope M2 relative / compared to 1/12 (the mass) of 1 mol of C-12 OR in which one mol C-12 (atom / isotope) has a mass of (exactly) 12 g	2						
2(b)	% abundance of ^{63}Cu = 72.5% % abundance of ^{65}Cu = 27.5% M1 correct algebraic expression AND correct calculation of x for one isotope % ab of ^{63}Cu = x $(x/100 \times 63) + ((1-x)/100 \times 65) = 63.55$ so $x = 72.5$ OR % ab of ^{65}Cu = x $(1-x)/100 \times 63 + x/100 \times 65 = 63.55$ so $x = 27.5$ M2 calculation of abundance of other isotope by $100 - x$	2						
2(c)(i)	metallic	1						
2(c)(ii)	diagram showing the bonding in a sample of copper  M1 diagram shows regular arrangement of spheres labelled as positively charged ions / +2 or +1 / cations M2 diagram shows surrounded by electrons and clearly labelled as 'delocalised electrons'	3						
2(d)(i)	M1 calculate the number mol $\text{S}_2\text{O}_3^{2-}$ added $20/1000 \times 0.10 = 2 \times 10^{-3} = 0.002$ (mol $\text{S}_2\text{O}_3^{2-}$) M2 calculate number mol CuSO_4 in 250cm^3 (1mol $\text{S}_2\text{O}_3^{2-}$: 1 mol CuSO_4) = 0.002 mol CuSO_4 in 25cm^3 so 0.02 mol CuSO_4 in 250cm^3	2						
2(d)(ii)	<table border="1"> <tr> <td>M1 amount of CuSO_4 in 10.68 g of $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$</td><td>$7.98 / (159.6) = \underline{0.05}$ (mol)</td></tr> <tr> <td>M2 amount of H_2O in 10.68 g of $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$</td><td>$(10.68 - 7.98) / 18 = 2.7 / 18 = \underline{0.15}$ (mol)</td></tr> <tr> <td>M3 value of x</td><td>(mol H_2O ÷ mol CuSO_4) = 3</td></tr> </table>	M1 amount of CuSO_4 in 10.68 g of $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$	$7.98 / (159.6) = \underline{0.05}$ (mol)	M2 amount of H_2O in 10.68 g of $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$	$(10.68 - 7.98) / 18 = 2.7 / 18 = \underline{0.15}$ (mol)	M3 value of x	(mol H_2O ÷ mol CuSO_4) = 3	3
M1 amount of CuSO_4 in 10.68 g of $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$	$7.98 / (159.6) = \underline{0.05}$ (mol)							
M2 amount of H_2O in 10.68 g of $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$	$(10.68 - 7.98) / 18 = 2.7 / 18 = \underline{0.15}$ (mol)							
M3 value of x	(mol H_2O ÷ mol CuSO_4) = 3							

Question	Answer	Marks
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May/June 2020 9701/23 · Q2 (a), (b), (c)(i), (c)(ii), (d)(i), (d)(ii)

3(b)(iii)	empirical formula of fructose CH_2O	1
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May/June 2020 9701/23 · Q3 (b)(iii)

3(b)	$\text{Al}(\text{OH})_3$ / aluminium hydroxide	1
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Oct/Nov 2020 9701/21 · Q3 (b)

4(d)(iii)	$\text{C}_{12}\text{H}_{20}\text{O}_2$	1
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Oct/Nov 2020 9701/22 · Q4 (d)(iii)

1(a)(i)	option 1 M1 the mass of a molecule OR the (weighted) average / (weighted) mean mass of the molecule(s)	1
	option 1 and M2 relative / compared to 1 / 12 (the mass) of an atom of carbon-12	1
	OR on a scale in which a carbon-12 atom / isotope has a mass of (exactly) 12 (units) option 2 M1 mass of one mol of molecules	
	option 2 M2 relative / compared to 1 / 12 (the mass) of 1 mol of C-12 OR which one mol C-12 (atom / isotope) has a mass of (exactly) 12 g	
1(a)(ii)	CO_2H	1
1(a)(iii)	$0.18/90 \times 2 \times 6.02 \times 10^{23} = 2.408 \times 10^{21}$ (atoms) OR 2.4(1) $\times 10^{21}$ (atoms) M1 no mole ethanedioic acid $0.18 / 90 = 0.0020$	1
	M2 no mole ethanedioic acid $\times 2$ $0.0020 \times 2 = 0.0040$	1
	M3 no mole ethanedioic acid $\times 6.02 \times 10^{23}$ 2.4×10^{21}	1
1(b)(ii)	(thermal) decomposition OR disproportionation	1

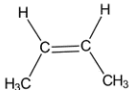
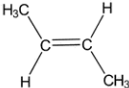
May/June 2021 9701/21 · Q1 (a)(i), (a)(ii), (a)(iii), (b)(ii)

5(b)(i)	(thermal) cracking	1
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May/June 2021 9701/21 · Q5 (b)(i)

4

4(a)(i)

	structural formula	name
A	$\text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2$	but-1-ene OR 1-butene
B		cis / Z but-2-ene OR cis / Z 2-butene
C		trans / E but-2-ene OR trans / E 2-butene
D	$\text{CH}_2=\text{C}(\text{CH}_3)_2$	(2) methyl prop(-1)-ene

M1 correct identification of but-1-ene (for **A**)

M2 correct identification of but-2-ene for **B** and **C**

M3 identification of cis / trans (Z / E) for **B** and **C** (in correct order)

M4 correct name of **D**

May/June 2021 9701/22 · Q4 (a)(i)

3(c)	% of O M1 $100 - 79.29 (= 20.71)$	1
	M2 express W and O as mol by / 183.8 and / 16 respectively	1
	M3 divide each by smallest number to give empirical formula WO_3	1

Question	Answer	Marks
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May/June 2021 9701/23 · Q3 (c)

2(d)(i)	M1 moles of $\text{NH}_3 = 1.50 \times 10^6 \times 10^6 + 17 = 8.82 \times 10^{10}$	2
	M2 mass of $\text{CaCN}_2 = \frac{\frac{1}{2} \times \text{M1} \times 80.1}{10^6} = 3.53 \times 10^6$	

Oct/Nov 2021 9701/21 · Q2 (d)(i)

3(d)(i)	proton / H^+ donor [1] fully dissociates (in aqueous solution / water / solvent) [1]	2
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March 2022 9701/22 · Q3 (d)(i)

1(e)(i)	1 / 12 (one twelfth) the mass of a carbon-12 / ^{12}C atom	1
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May/June 2022 9701/21 · Q1 (e)(i)

4(a)	M1 % / A_r for C H O M2 each % / A_r for C H O divided by the smallest value for % / A_r to give simplest whole number ratio / empirical formula M3 compare M_r from M2 ratio with 280 to deduce the actual molecular formula C $77.2 / 12 = 6.433$ 9(.03) H $11.4 / 1 = 11.4$ 16 O $11.4 / 16 = 0.7125$ 1 $M_r(\text{C}_9\text{H}_{16}\text{O}) = 140$ so molecular formula of V = $\text{C}_{18}\text{H}_{32}\text{O}_2$	3
	4(c)(ii) CHI_3	

May/June 2022 9701/21 · Q4 (a), (c)(ii)

2(c)(i)	$\text{Ra} + 2\text{H}_2\text{O} \rightarrow \text{Ra}(\text{OH})_2 + \text{H}_2$	1
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May/June 2022 9701/22 · Q2 (c)(i)

3(b)	evaluation, to give a value, based on calculation using: - all three correct bond energies [$\text{HI} = 299$, $\text{H}_2 = 436$, $\text{I}_2 = 151$] - correct use of stoichiometry to calculate ΔH for 1 mol HI $x = 1$ and $y = \frac{1}{2}$ - calculate a value for ΔH correctly i.e. $x(299) - y(436 + 151)$ $\Delta H = (+)5.5 \text{ kJ mol}^{-1}$	2
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May/June 2022 9701/22 · Q3 (b)

6(b)	C	:	H	:	O	1
	41.38 / 12		3.45 / 1		55.17 / 16	
	3.45		3.45		3.45 (so C ₍₁₎ H ₍₁₎ O ₍₁₎)	

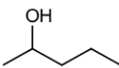
May/June 2022 9701/22 · Q6 (b)

3(a)(iv)	molecular formula $\text{C}_5\text{H}_{10}\text{O}$	1
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Oct/Nov 2022 9701/22 · Q3 (a)(iv)

1(a)(ii)	M1 (weighted) average / mean mass of the isotopes / average mass of the atom(s) (of an element)	1
	M2 compared to (the mass of) the unified atomic mass unit	1
1(a)(iii)	$69.723 = 68.926x + 70.925(1-x) \therefore x = 0.6013$ $/ 69.723 = \frac{68.926x + 70.925(100-x)}{100}$	1
	60.13%	1

Oct/Nov 2022 9701/23 · Q1 (a)(ii), (a)(iii)

4(b)(ii)	CH_2O	1
4(c)	 M1 molecule with 5C atoms and 1 alcohol group M2 molecule with $-\text{CH}(\text{CH}_3)\text{OH}$	2

Question	Answer	Marks
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May/June 2023 9701/21 · Q4 (b)(ii), (c)

1(b)(i)	(the mass of) one twelfth of the mass of a C-12 / ^{12}C atom (or isotope)	1
1(b)(ii)	average mass of the isotopes of an element compared to the unified atomic mass unit	1
1(b)(iii)	$(62.93 \times 69.15) \div 100 + (64.928 \times 30.85) \div 100 = 63.55 / 63.546$	1

May/June 2023 9701/23 · Q1 (b)(i), (b)(ii), (b)(iii)

4(b)(iii)	M1 $[\text{HI}]$ at equilibrium $= 1.7 / 2 = 0.85$ M2 idea that $[\text{H}_2] = [\text{I}_2]$ in equilibrium mixture M3 correct calculation based on correct rearrangement of equation in (b)(ii), 0.0217 and their M1 $= 0.125$	3
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May/June 2023 9701/23 · Q4 (b)(iii)

1(e)	moles of $\text{NaBiO}_3 = 21.50 / 1000 \times 0.100$ ($= 2.15 \times 10^{-3} \text{ mol}$)	1
	moles of Mn^{2+} in dil. $= 2.15 \times 10^{-3} \times 2 / 5 \times 40$ ($= 0.0344 \text{ mol}$)	1
	conc. saturated $\text{Mn}^{2+} = 0.0344 \times 1000 / 100 = 0.344 \text{ mol dm}^{-3}$	1

Question	Answer	Marks
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March 2024 9701/22 · Q1 (e)

1(d)(ii)	M1 sodium chloride M2 Cl^- is not a strong enough reducing agent to reduce H_2SO_4 M3 Br^- & I^- are strong enough reducing agents to react (further) with (the S in) H_2SO_4 <i>Alternative M2 and M3</i> M2 ability to behave as reducing agents increases down the group M3 EITHER Cl^- is not strong enough to reduce H_2SO_4 OR Br^- and I^- react (further) with (the S in) H_2SO_4	3
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Question	Answer	Marks
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May/June 2024 9701/21 · Q1 (d)(ii)

6(a)(iii)	$\text{C}_{13}\text{H}_{20}\text{O}_3$	1
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May/June 2024 9701/21 · Q6 (a)(iii)

2(a)	58% / no change / stays the same AND catalysts don't affect yield / iron is a catalyst	1
2(b)(ii)	(increase in temperature / energy from A to C (so)) M1 more collisions with particles that have $E > E_a$ AND increase frequency of effective collisions M2 (initial) rate (of the forward reaction) increases	2
2(d)(ii)	M1 unburned hydrocarbons combine with NO and / NO_2 M2 to form PAN / peroxyac(et)yl nitrate	2

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Question	Answer	Marks
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May/June 2024 9701/23 · Q2 (a), (b)(ii), (d)(ii)

5(d)(iii)	$\text{C}_8\text{H}_{12}\text{O}_4 + 8[\text{H}] \rightarrow \text{C}_8\text{H}_{16}\text{O}_2 + 2\text{H}_2\text{O}$	1
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May/June 2024 9701/23 · Q5 (d)(iii)

1(c)(ii)	$\frac{190.96 \times 15.18 + 192.96 \times 34.82}{50.00}$	1
	= 192.35	1

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Question	Answer	Marks
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Oct/Nov 2024 9701/21 · Q1 (c)(ii)

1(b)(iii)	$92.91 \times 0.909 + 180.95 \times 0.091$	1
	= 100.92	1

Question	Answer	Marks
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Oct/Nov 2024 9701/22 · Q1 (b)(iii)

4(e)(ii)	oxidising agent	1
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Oct/Nov 2024 9701/22 · Q4 (e)(ii)

1(c)(ii)	$\frac{190.96 \times 15.18 + 192.96 \times 34.82}{50.00}$	1
	= 192.35	1

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Oct/Nov 2024 9701/23 · Q1 (c)(ii)

Question	Answer	Marks
1(a)(iii)	ratio of moles of P : Cl = $\frac{30.4}{31.0} : \frac{69.6}{35.5} = 0.98 : 1.96 (= 1 : 2)$ molecular formula = P ₂ Cl ₄	2

March 2025 9701/22 · Q1 (a)(iii)

2(b)(i)	M1 method showing each abundance multiplied by m/e value • (5.9 × 54) and (91.9 × 56) and (2.2 × 57) OR • (0.59 × 54) and (9.19 × 56) and (0.22 × 57) M2 the three values from M1 expressed as a percentage and added together correctly with final answer to 1 d.p. $\frac{5.9}{100} \times 54 + \frac{91.9}{100} \times 56 + \frac{2.2}{100} \times 57 = 55.9$	2
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May/June 2025 9701/21 · Q2 (b)(i)

3(c)	(forward) reaction is exothermic (a + b) > c	2
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Question	Answer	Marks
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May/June 2025 9701/21 · Q3 (c)

4(a)	C ₃ H ₄ O ₃	1
4(b)(i)	(28.40 / 1000 × 0.0005) = 1.42 × 10 ⁻⁵ mol	1

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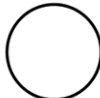
Question	Answer	Marks
4(b)(ii)	(1.42 × 10 ⁻⁵ × 176 × 200 / 5) = 0.099968 M1 correct method to deduce mass of vit C in 5 cm ³ sample (1.42 × 10 ⁻⁵ × 176) = 2.49 × 10 ⁻³ M2 correct calculation for mass of vit C in original solution (2.49 × 10 ⁻³ × 200 / 5) = 0.099968 OR M1 correct method to deduce amount, mol, vit C in 5 cm ³ sample (1.42 × 10 ⁻⁵ × 200 / 5) = 5.68 × 10 ⁻⁴ M2 correct calculation for mass of vit C in original solution = M1 × 176 (5.68 × 10 ⁻⁴) × 176 = 0.099968	2
4(b)(iii)	oxidising agent	1

May/June 2025 9701/21 · Q4 (a), (b)(i), (b)(ii), (b)(iii)

2(a)(ii)	M1 relative abundance of unknown isotope = $(100 - 91.9 - 6.0) = 2.1\%$ M2 $55.8 = (53.9 \times 6.0 + 55.9 \times 91.9 + ? \times M1) / 100 = 56.9$	2
2(b)	1 (pair)	1

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Question	Answer	Marks						
2(c)		1						
2(d)	<table><tr><td>species present in an ion of 56-Fe^{3+}</td><td>number</td></tr><tr><td>electrons</td><td>M1 23</td></tr><tr><td>M2 neutrons</td><td>30</td></tr></table>	species present in an ion of 56-Fe^{3+}	number	electrons	M1 23	M2 neutrons	30	2
species present in an ion of 56-Fe^{3+}	number							
electrons	M1 23							
M2 neutrons	30							
2(e)	M1 smaller / decreases M2 loss of outer / valence shell (of electrons) OR loss of electrons so increase in (force of) attraction from nucleus OR loss of electrons so increase nuclear attraction	2						

Question	Answer	Marks
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May/June 2025 9701/22 · Q2 (a)(ii), (b), (c), (d), (e)

3(b)(i)	H_2 / hydrogen AND some X / alkene left(over) / remains (at the end of this reaction)	1
3(c)	method 1 – breaking all bonds in molecules $(2 \times 610) + (2 \times 436) + (10 \times 410) + (3 \times 350) - (14 \times 410) - (5 \times 350)$ - energy involved when all bonds are broken = (7242) - energy involved when all bonds are made = (7490) - energy to break bonds – energy to make bonds $= (7242 - 7490) = -248$ method 2 – ignore any bonds that do not change from reactants to products $(2 \times 610) + (2 \times 436) - (4 \times 410) - (2 \times 350)$ - energy involved when all bonds are broken = (2092) - energy involved when all bonds are made = (2340) - energy to break bonds – energy to make bonds $(2092 - 2340) = -248$	2

May/June 2025 9701/22 · Q3 (b)(i), (c)

5(b)(i)	$5.00 \times 10^{-3} \times 36.65 / 1000$ $= 1.833 \times 10^{-4} / 1.8325 \times 10^{-4}$	1
5(b)(ii)	M1 expression and / or correct calculation to show how the amount of vitamin C in 150 g of lemon peel is calculated $1.8325 \times 10^{-4} \text{ mol} \times 176 \times 4$ M2 correct calculation based on $(M1 / 150) \times 100 = 0.086(\%)$ Using 1.8325×10^{-4} for M1 , M2 = 0.086 OR 0.087(%) Alternative answer using 7.65×10^{-4} : M1 $7.65 \times 10^{-4} \times 176 \times 4 = 0.5386 / 0.539$ M2 correct calculation based on $(M1 / 150) \times 100 = 0.359 / 0.36(\%)$	2

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Question	Answer	Marks
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May/June 2025 9701/22 · Q5 (b)(i), (b)(ii)

4(a)(ii)	Na ₂ S ₂ O ₃ because reaction stops before all the HCl is used up. OR Na ₂ S ₂ O ₃ because there is still HCl remaining (when the reaction has stopped)	1
4(b)(ii)	M1 weaker dipole moment (in SO ₂) M2 electronegativity (difference) is larger (/ 1.4) for H and O than for S and O (/ 0.9) OR S=O bond is less polar than H—O OR stronger dipoles in S=O / SO ₂	2

Question	Answer	Marks
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May/June 2025 9701/23 · Q4 (a)(ii), (b)(ii)

5(a)(i)	C ₂ H ₃ O	1									
5(a)(ii)	<table border="1"> <tr> <th>reagent</th><th>observation when reagent is added to W</th><th>structural formula of organic product when reagent is added to W</th></tr> <tr> <td>Na</td><td>fizz / bubbles etc / OR solid / Na disappears / dissolves</td><td>CH₂C(CH₃)CO₂Na OR CH₂C(CH₃)CO₂⁻ Na⁺</td></tr> <tr> <td>Br₂ in the dark</td><td>brown to colourless / decolourise</td><td>CH₂BrCBr(CH₃)CO₂H</td></tr> </table>	reagent	observation when reagent is added to W	structural formula of organic product when reagent is added to W	Na	fizz / bubbles etc / OR solid / Na disappears / dissolves	CH ₂ C(CH ₃)CO ₂ Na OR CH ₂ C(CH ₃)CO ₂ ⁻ Na ⁺	Br ₂ in the dark	brown to colourless / decolourise	CH ₂ BrCBr(CH ₃)CO ₂ H	4
reagent	observation when reagent is added to W	structural formula of organic product when reagent is added to W									
Na	fizz / bubbles etc / OR solid / Na disappears / dissolves	CH ₂ C(CH ₃)CO ₂ Na OR CH ₂ C(CH ₃)CO ₂ ⁻ Na ⁺									
Br ₂ in the dark	brown to colourless / decolourise	CH ₂ BrCBr(CH ₃)CO ₂ H									
5(b)(ii)		1									
5(b)(iii)	reducing agent	1									
5(b)(iv)	methanol / CH ₃ OH AND conc(entrated) (sulfuric) acid (catalyst)	1									

May/June 2025 9701/23 · Q5 (a)(i), (a)(ii), (b)(ii), (b)(iii), (b)(iv)

3(a)(i)	0.00658(0) mol	1
3(a)(ii)	M1 I ₂ in 25.0 cm ³ 0.00658 / 2 = 0.00329 (mol) M2 0.00329 × 1000 / 25.0 = 0.132 (mol) alternative answer using 9.42 × 10 ⁻³ : M1 0.00471 M2 0.1884	2
3(b)	M1 0.2 – 0.154 = 0.046 (mol H ₂ and / or I ₂ reacts) M2 mol H ₂ at equilibrium 0.1 – 0.046 = 0.054 M3 mol HI at equilibrium 0.3 + (0.046 × 2) = 0.392	3
3(d)(ii)	M1 HCl is more stable AND (because) Cl atom is smaller / less distance between electron pair and nucleus / shorter (H-X) bond length M2 (In HCl) stronger attraction between nucleus and shared pair of electrons OR (In HCl) (fewer shells of electrons so) less shielding OR (In HCl) greater orbital overlap so stronger interaction	2

May/June 2025 9701/24 · Q3 (a)(i), (a)(ii), (b), (d)(ii)

4(a)	C ₅ H ₁₀ O ₂	1
4(b)	propyl ethanoate	1
4(d)(iii)	M1 step 1 PCl ₅ and heat OR HCl(g) OR PCl ₅ OR SOCl ₂ OR NaCl / KCl and conc. H ₂ SO ₄ / conc. H ₃ PO ₄ M2 step 2 reagent KCN M3 conditions for step 2 dissolved in ethanol AND heat	3

Question	Answer	Marks
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May/June 2025 9701/24 · Q4 (a), (b), (d)(iii)

6(a)(ii)	M1 $\frac{85.7}{12}$ or 7.14 1 C : H : $\frac{14.3}{1}$ or 14.3 : 2 M2 CH₂	2
6(a)(iii)	alkene(s)	1
6(c)(ii)	C ₁₀ H ₁₈	1
6(c)(iii)	(C ₄ H ₉) ⁺	1

May/June 2025 9701/24 · Q6 (a)(ii), (a)(iii), (c)(ii), (c)(iii)

1(a)(iv)	The fourth isotope has any value of RIM less than 51.996	1
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Oct/Nov 2025 9701/21 · Q1 (a)(iv)

3(a)	simplest /lowest (whole number / integer) ratio of atoms (of each element) in a compound / molecule	1
3(c)(ii)	M1 C ₅ H ₁₀ + Cl• → C ₅ H ₉ • + HCl M2 C ₅ H ₉ • + Cl ₂ → C ₅ H ₉ Cl + Cl•	2
3(c)(iii)	termination	1
3(d)(i)	HCl (g)	1

Oct/Nov 2025 9701/21 · Q3 (a), (c)(ii), (c)(iii), (d)(i)

1(a)(iii)	M1 (relative) isotopic mass. OR (relative isotopic) mass of Mn-55 and Mn-53 M2 (relative) abundance of each isotope	2
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Oct/Nov 2025 9701/22 · Q1 (a)(iii)

3(c)	cracking	1
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Oct/Nov 2025 9701/22 · Q3 (c)

3(c)(iii)	termination	1
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Oct/Nov 2025 9701/23 · Q3 (c)(iii)

4(b)(iii)		reaction of V with propan-2-ol	3
	type of reaction	M1 condensation	
	functional group formed	M2 ester	
	molecular formula of organic product W	M3 C ₉ H ₁₈ O ₂	

Oct/Nov 2025 9701/24 · Q4 (b)(iii)