Question Number	Answer	Mark
15	**The only correct answer is D** ($C_{13}H_{28}$) ***A*** *is incorrect because* $2(C_2H_4)+2(C_3H_6)+(C_3H_8) \neq C_8H_{18}$ ***B*** *is incorrect because* $2(C_2H_4)+2(C_3H_6)+(C_3H_8) \neq C_{10}H_{22}$ ***C*** *is incorrect because* $2(C_2H_4)+2(C_3H_6)+(C_3H_8) \neq C_{11}H_{24}$	**(1)**

Question Number	Answer	Mark
16	**The only correct answer is A** (butene, pentane and propene) ***B*** *is not correct because there are too many hydrogen atoms in the products* ***C*** *is not correct because there are too few carbon atoms in the products* ***D*** *is not correct because there are too many carbon atoms in the products*	**(1)**

Question Number	Answer	Mark
15	**The only correct answer is A** () ***B*** *is not correct because the symbols for oxidising and health hazard are shown* ***C*** *is not correct because the symbol for oxidising is shown* ***D*** *is not correct because the symbol for health hazard is shown*	**(1)**

Question Number	Answer	Mark
5	**The only correct answer is D** ($NH_3(g)$) ***A*** *is incorrect because it is not a polar molecule* ***B*** *is incorrect because it is not a polar molecule* ***C*** *is incorrect because it is not a polar molecule*	**(1)**

Question Number	Answer	Mark
13	**The only correct answer is C** (0.00004%) **A** *is not correct because the answer shows the percentage equal to ppm* **B** *is not correct because the answer shows the ppm divided by 100* **D** *is not correct because the correct answer has been divided by 100*	**(1)**

Question Number	Answer	Mark
8	**The only correct answer is D** (87%) ***A*** *is incorrect because this is the atom economy of water* ***B*** *is incorrect because this is the economy by moles rather than by mass* ***C*** *is incorrect because this is the value ignoring the stoichiometry (balancing) of the equation for the products*	**(1)**

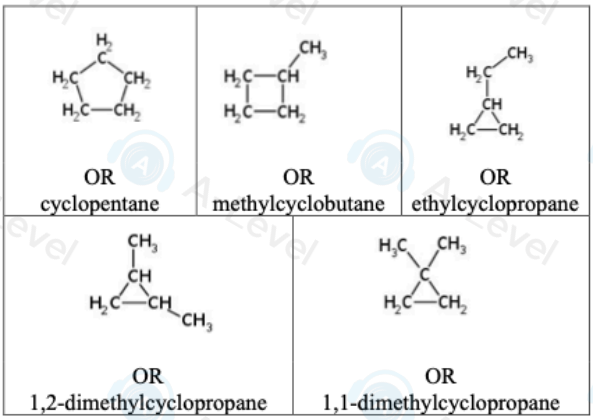
Question Number	Answer	Additional Guidance	Mark
24(a)(i) Clip all	• rearrangement of $pV = nRT$ **(1)** • conversion of dm^3 to m^3 **(1)** • substitution in correctly rearranged expression **(1)** • calculation of value of n **(1)**	Example of calculation $n = pV \div RT$ $V = 0.00179 / 1.79 \times 10^{-3}$ $n = (110\,000 \times 0.00179) \div (8.31 \times 473)$ Allow TE in M3 from incorrect conversion from dm^3 to m^3 $n = 0.0501$ (mol) / 5.01×10^{-2} (mol) / 0.050094 (mol) / 5.0094×10^{-2} (mol) / 0.05 (mol) / 5×10^{-2} (mol) Allow TE for M4 from incorrect values shown in a correctly rearranged expression Ignore SF throughout Correct answer with some working scores 4	**(4)**

Question Number	Answer	Additional Guidance	Mark
24(a)(ii)	• calculation of M_r of X	Example of calculation $M_r = 3.5 \div 0.0500 = 70$ Accept 69.869 Allow TE on incorrect moles in (a)(i) provided answer >1	**(1)**

Question Number	Answer	Additional Guidance	Mark
24(a)(iii)	• calculation of moles of carbon **and** moles of hydrogen **(1)** • calculation of ratio **and** gives empirical formula **(1)**	Example of calculation 85.7 ÷ 12 = 7.1417 **and** 14.3 ÷ 1 = 14.3 14.3 ÷ 7.1417 = 2.0023 CH_2 Ignore SF throughout Correct answer with no working scores (2)	**(2)**

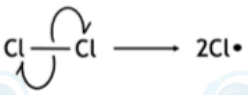
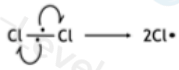
Question Number	Answer	Additional Guidance	Mark
24(a)(iv)	• molecular formula	Example of calculation ans(a)(ii) ÷ ans(a)(iii) 70 ÷ 14 = 5 C_5H_{10} Allow TE on (a)(ii) and (a)(iii) Answer with no working scores 1	**(1)**

Question Number	Answer	Additional Guidance	Mark
24(b)	An answer that makes reference to the following point: • no (C=C) double bonds are present / molecule is not unsaturated / molecule is not an alkene / only single bonds are present / molecule is saturated / molecule is an alkane	Allow it is a cycloalkane Ignore it does not contain oxygen	**(1)**

Question Number	Answer	Additional Guidance	Mark
24(c)	An answer that makes reference to the following points: • one possible structural isomer **(1)** • a second structural isomer **(1)**	 OR cyclopentane OR methylcyclobutane OR ethylcyclopropane OR 1,2-dimethylcyclopropane OR 1,1-dimethylcyclopropane Allow any type of displayed or skeletal formulae Allow 1-methylcyclobutane and 1-ethylcyclopropane If name and formula are given, both must be correct Allow TE on formula from (a)(iv) If answer in (b) is alkene, then allow 1 mark for two correct alkenes using formula in (a)(iv)	**(2)**

(Total for Question 24 = 11 marks)

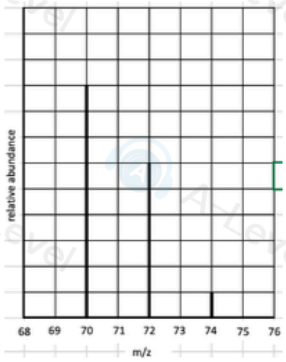
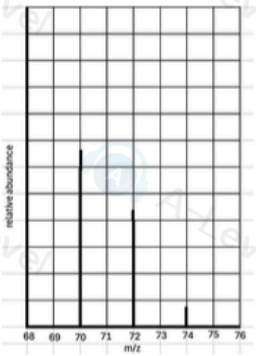
Question Number	Answer	Additional Guidance	Mark
22(a)	An answer that makes reference to the following point: • free-radical substitution reaction		(1)

Question Number	Answer	Additional Guidance	Mark
22(b)(i)	An answer that makes reference to the following points: • a balanced equation (1) • a pair of single headed arrows (fish hooks) on the Cl—Cl bond in the reactant (1)	 Do not award charges  Allow 	(2)

Question Number	Answer	Additional Guidance	Mark
22(b)(ii)	An answer that makes reference to the following points: • first propagation (1) • second propagation (1)	The radical could be anywhere on the organic materials $CH_3CH_2CH_2CH_3 + Cl\bullet \rightarrow CH_3CH_2CH_2CH_2\bullet + HCl$ Allow $C_4H_{10} + Cl\bullet \rightarrow C_4H_9\bullet + HCl$ $CH_3CH_2CH_2CH_2\bullet + Cl_2 \rightarrow CH_3CH_2CH_2CH_2Cl + Cl\bullet$ Allow $C_4H_9\bullet + Cl_2 \rightarrow C_4H_9Cl + Cl\bullet$ Penalise use of incorrect alkane once only	(2)

Question Number	Answer	Additional Guidance	Mark
22(b)(iii)	An answer that makes reference to the following point: • termination step fusion of two butyl radicals	$CH_3CH_2CH_2CH_2\bullet + CH_3CH_2CH_2CH_2\bullet \rightarrow CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$ Allow $C_4H_9\bullet + C_4H_9\bullet \rightarrow C_8H_{18}$ Do not award if charges are shown	(1)

Question Number	Answer		Additional Guidance	Mark
22(c)	Method		Example of calculation	(3)
	• calculation of moles of butane	(1)	10/58 = 0.17241 mol butane	
	• calculation of theoretical mass of trichlorobutane	(1)	mol trichlorobutane 0.17241 0.17241 x 161.5 = 27.844(g)	
	• % yield	(1)	1/ 27.844 x 100 = 3.591%	
	Alternative method			
	• calculation of moles of butane	(1)	10/58 = 0.17241 mol butane	
	• calculation of actual moles of trichlorobutane	(1)	$1/161.5 = 6.19195 \times 10^{-3}$	
	• % yield ((M2/M1) x 100))	(1)	$[6.19195 \times 10^{-3} / 0.17241] \times 100$ = 3.591%	
			TE throughout, but final answer must be less than 100% Correct answer with some working scores 3 Ignore SF except for 1 SF	

Question Number	Answer		Additional Guidance	Mark
22(d)	An answer that makes reference to the following points:  		 	(2)
	• 3 lines drawn at 70, 72, 74	(1)		
	• ratio 9 (at 70):6 (at 72):1 (at 74)	(1)	Accept 56.25% (5.6 squares) : 37.5% (3.8 squares): 6.25% (0.6 squares) assuming 1 square is 10%	

(Total for Question 22 = 11 marks)