

Question		Answer	Mark	Guidance
1	(a)	B ✓	1	ALLOW CF ₂ CF ₂ OR C ₂ F ₄ OR tetrafluoroethene
	(b)	(i) <div style="text-align: center;"> </div>	1	ALLOW correct structural OR displayed OR skeletal OR mixture of the above ALLOW <i>E</i> isomer <div style="text-align: center;"> </div>
		(ii) HCl ✓	1	DO NOT ALLOW Cl ₂ IGNORE names IGNORE nitrogen oxides / NO _x
	(c)	(i) ANY TWO FROM THE FOLLOWING ✓ Low reactivity OR will not burn/non-flammable Volatile OR low boiling point non-poisonous OR non-toxic	1	ALLOW inert OR stable DO NOT ALLOW inflammable ALLOW it is a gas IGNORE easily compressed IGNORE not harmful IGNORE references to solubility

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(ii)	<p><i>Benefit of ozone layer to life (1 mark)</i></p> <p>Ozone absorbs UV (radiation)</p> <p>UV at Earth's surface is reduced ✓</p> <p>OR-----</p> <p><i>Maintenance of O₃ concentration (1 mark)</i></p> $O_3 \rightleftharpoons O_2 + O \checkmark$ <p>O</p> <p>-----</p> <p><i>Production of radicals from G (1 mark)</i></p> $2C l_2 \longrightarrow C l + CF_2C l \checkmark$ <p>-----</p> <p>CF</p> <p><i>Breakdown of O₃ (2 marks)</i></p> $C l + O_3 \longrightarrow C l O + O_2 \checkmark$ $C l O + O \longrightarrow C l + O_2$ <p>OR</p> $C l O + O_3 \longrightarrow C l + 2O_2 \checkmark$ <p>C</p>	5	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>For all equations, IGNORE dots on radicals</p> <p>-----</p> <p>Essential idea for first mark is that UV is removed in some way.</p> <p>ALLOW Prevents UV damaging life or stated type of damage, e.g. cataracts, skin cancer, mutation, crop damage</p> <p>DO NOT ALLOW ozone absorbs IR</p> <p>-----</p> <p>ALLOW</p> $O_3 \longrightarrow O_2 + O$ $O_2 + O \longrightarrow O_3$ <p>AND</p> <p>DO NOT ALLOW $2O_3 \rightleftharpoons 3O_2$</p> <p>OR $O_3 + O \longrightarrow 2O_2$ for this mark</p> <p>-----</p> <p>DO NOT ALLOW equations with other CFCs</p> <p>DO NOT ALLOW $CF_2C l_2 \longrightarrow 2C l + CF_2$</p> <p>-----</p> <p>These are the only acceptable equations</p> <p>IGNORE overall equation (<i>does not show role of catalyst</i>) e.g. $O_3 + O \longrightarrow 2O_2$</p>

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	(iii)	D ✓	1	ALLOW CHF ₂ Cl ALLOW B OR C ₂ F ₄ OR CF ₂ CF ₂
(d)	(i)	bond vibrates (more) OR bond bends (more) OR bond stretches (more) ✓	1	BOND essential IGNORE molecule vibrates/rotates Assume "It" refers to the molecule and is insufficient DO NOT ALLOW any reference to bond breaking DO NOT ALLOW a stated bond if not present in C and F e.g. C–O, C–H not prese
	(ii)	Cl ₃ C ⁺ ✓ CF ₂ Cl ⁺ ✓	2	ALLOW 1 mark for Cl ₃ C AND CF ₂ Cl <i>i.e. no + charge used</i> ALLOW 1 mark for Cl ₃ C ⁻ AND CF ₂ Cl ⁻ <i>i.e. – charge used on both</i>
Total			13	

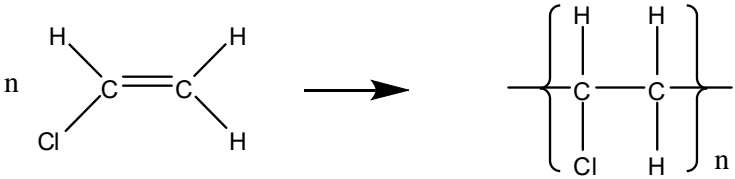
Question			Answer	Mark	Guidance
2	(a)	(i)	But-1-ene ✓ $\begin{array}{c} \text{H} \quad \text{C}_2\text{H}_5 \\ \quad \\ \text{C} = \text{C} \\ \quad \\ \text{H} \quad \text{H} \quad \checkmark \end{array}$	2	ALLOW displayed formula ALLOW C ₂ H ₅ CH=CH ₂
		(ii)	Poly(ethenol) has (many) O–H group(s) ✓ Poly(ethenol) forms hydrogen bonds with water ✓	2	ALLOW poly(ethenol) has hydroxyl group OR hydroxy group OR is an alcohol DO NOT ALLOW hydroxide DO NOT ALLOW 'it forms hydrogen bonds'
	(b)		CO is a poisonous gas ✓ HCl is acidic/forms acid rain OR corrosive OR HCl will react with metalwork OR HCl will react with marble/limestone buildings ✓ ANY TWO METHODS FROM: Method 1 Remove HCl by reacting with a base OR remove HCl by use of a gas scrubber ✓ Method 2 Develop ways of ensuring all CO is oxidised to CO ₂ OR ensure complete combustion to avoid making CO ✓ Method 3 Remove CO ₂ by CCS ✓ Method 4 (Use methods to remove the need for incineration such as) separation AND recycling of the plastics/polymers ✓ Method 5 (Use methods to remove the need for incineration such as) developing biodegradable/compostable plastics/polymers ✓	4	ANNOTATE ANSWER WITH TICKS AND CROSSES ALLOW CO reduces amount of oxygen transported in blood Forming carboxyhaemoglobin/binds with haemoglobin is not sufficient IGNORE HCl is toxic IGNORE references to ozone layer and greenhouse effect Methods 1 to 3 must be linked to a gas IGNORE reference to catalytic converter ALLOW specific examples of CCS e.g. CO ₂ stored as a metal carbonate / CO ₂ stored deep under sea / CO ₂ stored in rock ALLOW (Use methods to remove the need for incineration such as) use of plastics/polymers as a feedstock for making other chemicals

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(c)	<p>ANY TWO FROM:</p> <p>Idea that all countries contribute towards pollution ✓</p> <p>Idea that atmospheric pollution (from incineration travels) across borders OR waste plastics travel across borders / waste plastics travel across the sea ✓</p> <p>Cooperation means that scientists can share ideas OR scientists can warn governments of risk OR world-wide legislation can be introduced OR allows monitoring of pollution in different countries OR richer countries can help poorer countries introduce pollution controls ✓</p> <p>One country cannot control pollution unless all countries do ✓</p>	2	<p>ALLOW some countries produce more pollution than others.</p> <p>ALLOW reference to protocols</p>
Total		10	

Question			Expected Answers	Marks	Additional Guidance
3	(a)	(i)	Infrared (radiation absorbed) ✓ by (C–H) bond vibration ✓	2	ALLOW bond stretching OR bond bending DO NOT ALLOW molecules vibrating
		(ii)	Greater concentration of carbon dioxide OR more carbon dioxide is being made ✓	1	ALLOW carbon dioxide is the main contributor to global warming DO NOT ALLOW any response that states that CO ₂ causes ozone depletion ALLOW C=O bonds absorb IR more readily than C–H bonds ALLOW carbon dioxide has a greater greenhouse effect

Question	Expected Answers	Marks	Additional Guidance
(b)	<p>Any five from the following: Developing carbon capture AND storage ✓</p> <p>One example of CCS ✓</p> <p>Second example of CCS ✓</p> <p>Provide evidence to governments OR international conferences (e.g. Kyoto) OR reports to United Nations etc ✓</p> <p>Educating society OR writing in journals OR producing documentaries OR writing books OR making posters ✓</p> <p>Monitoring atmospheric changes ✓</p> <p>Develop alternative energy sources ✓ One example of an alternative energy source e.g. develop fuel cells OR developing solar power OR fuels that do not produce CO₂ ✓</p> <p>(Develop) more efficient engines for transport OR lean burn engines OR hybrid engines OR electric cars ✓</p> <p>Find uses for carbon dioxide OR named use: e.g. dry cleaning OR making decaffeinated coffee OR blowing agent OR fizzy drinks, etc ✓</p>	5	<p>carbon, capture AND storage required ALLOW CCS</p> <p>Examples of CCS</p> <p>deep in the oceans OR on the sea-bed ✓ DO NOT ALLOW dissolve CO₂ in the sea OR stored in ocean</p> <p>storage in geological formations OR piped into disused or partially filled oil wells or porous rocks OR under the sea-bed ✓</p> <p>by reaction with metal oxides OR reaction to form (solid) carbonates OR stored as a carbonate OR equation to show formation of metal carbonate ✓ IGNORE mineral storage</p> <p>ALLOW idea of biofuels only if linked to carbon-neutrality</p> <p>IGNORE reforestation IGNORE reference to CFCs</p> <p>DO NOT ALLOW use less carbon dioxide</p>

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	(c)	<p>Any two from the following:</p> <p>There are times when CO₂ has a high concentration and the temperature is also high</p> <p>OR</p> <p>There are times when CO₂ has a low concentration and the temperature is low ✓</p> <p>It is impossible to measure with certainty the average temperature years ago ✓</p> <p>There are other gases that may cause a greenhouse effect</p> <p>OR</p> <p>There are other factors that may cause a greenhouse effect ✓</p> <p>There are very few anomalous results ✓</p>	2	<p>ALLOW a (positive) correlation between temperature and carbon dioxide concentration but DO NOT ALLOW just 'a correlation'</p> <p>IGNORE 'graphs are the same shape' IGNORE 'graphs are similar'</p>
		Total	10	

Question		Answer	Mark	Guidance
4	(a)	 <p data-bbox="323 592 747 624">Correct polymer with side links ✓</p> <p data-bbox="323 663 995 725">Balanced equation for formation of correct polymer - correct use of n in the equation and brackets ✓</p>	2	<p data-bbox="1226 381 1990 412">Displayed formulae MUST be used to award each mark</p> <p data-bbox="1226 655 1885 749">n on LHS can be at any height to the left of formula AND n on the RHS must be a subscript (essentially below the side link)</p>
	(b)	(i) $\text{CH}_2\text{CHCl} + 2\text{O}_2 \rightarrow \text{CO} + \text{CO}_2 + \text{HCl} + \text{H}_2\text{O}$ ✓	1	<p data-bbox="1226 804 2018 867">ALLOW any other correctly balanced equation with the same reactants and products</p> <p data-bbox="1226 867 1608 898">ALLOW $\text{C}_2\text{H}_3\text{Cl}$ for CH_2CHCl</p>
		(ii) Sodium hydrogencarbonate neutralises HCl ✓	1	<p data-bbox="1226 906 2018 969">Assume that 'it' refers to sodium hydrogencarbonate but DO NOT ALLOW other chemicals e.g. sodium</p> <p data-bbox="1226 1008 1581 1039">ALLOW NaHCO_3 is a base</p> <p data-bbox="1226 1039 1850 1070">ALLOW forms a salt or sodium chloride or NaCl</p> <p data-bbox="1226 1070 1986 1133">ALLOW equation to show formation of NaCl from NaHCO_3 and HCl even if not balanced.</p> <p data-bbox="1226 1133 1430 1165">IGNORE reacts</p>

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	(c)	<p>ANY TWO from</p> <p>abundance (in atmosphere) OR amount (in atmosphere) OR (atmospheric) concentration OR percentage (in air) ✓</p> <p>OR</p> <p>ability to absorb infrared/IR (radiation)✓</p> <p>OR</p> <p>residence time ✓</p>	2	ALLOW absorption of infrared/IR	
	(d)	(i)	Any balanced equation between a metal oxide and carbon dioxide to form a carbonate e.g $\text{CaO} + \text{CO}_2 \longrightarrow \text{CaCO}_3$ ✓	1	ALLOW MO for metal oxide
		(ii)	<p>ANY ONE FROM</p> <p>deep in oceans OR in geological formations OR (deep) in rocks OR in mines OR in oil wells OR in gas fields ✓</p>	1	<p>Assume that 'it' refers to carbon dioxide but DO NOT ALLOW carbon</p> <p>DO NOT ALLOW reacted with oxides or stored as carbonates.</p>
Total			8		

Question		Answer	Marks	Guidance
5	(a)	N ✓	1	ALLOW CF ₃ CFCI ₂
	(b) (i)	S ✓	1	ALLOW CH ₃ CHBrCH ₂ CHICH ₃
	(ii)	<p>curly arrow from HO⁻ to carbon atom of C-Br bond ✓</p> <p>Dipole shown on C-Br bond, C^{δ+} and Br^{δ-}, and curly arrow from C-Br bond to the halogen atom – arrow must be very close to the bond ✓</p> <p>correct products of the reaction – not ambiguous with the C₃H₇ ✓</p> <div style="text-align: center;"> <p style="text-align: center;"> $\begin{array}{c} \text{H} \\ \\ \text{C}_3\text{H}_7-\text{C}^{\delta+}-\text{Br}^{\delta-} \\ \\ \text{H} \end{array} \quad \begin{array}{c} \curvearrowright \\ \curvearrowright \\ \curvearrowright \\ \text{:OH}^- \end{array}$ \downarrow $\begin{array}{c} \text{H} \\ \\ \text{CH}_3\text{CH}_2\text{CH}_2-\text{C}-\text{OH} \\ \\ \text{H} \end{array} \quad + \quad \text{Br}^-$ </p> </div> <p>nucleophilic substitution ✓</p>	4	<p>The curly arrow must start from the oxygen atom of the OH⁻, and must start either from a lone pair or from the negative charge. No need to show lone pair if curly arrow came from negative charge</p> <p>DO NOT ALLOW attack by KOH or K⁺OH⁻</p> <div style="border: 1px solid black; padding: 10px; margin-top: 10px;"> <p>ALLOW S_N1</p> <p>Dipole shown on C-Br bond, C^{δ+} and Br^{δ-}, and curly arrow from C-Br bond to the halogen atom – arrow must be very close to the bond ✓</p> <p>Correct carbocation drawn AND curly arrow from HO⁻ to the carbocation (the curly arrow must start from the oxygen atom of the OH⁻, and must start either from a lone pair or from the negative charge. No need to show lone pair if curly arrow came from negative charge) ✓</p> <p>Correct products of the reaction – not ambiguous with the C₃H₇ ✓</p> <p>nucleophilic substitution ✓</p> </div>

Question		Answer	Marks	Guidance
	(b) (iii)	C-I bond is weaker than C-Br bond OR C-I has a lower bond enthalpy than C-Br bond OR C-I bond is longer than C-Br bond AND C-I bond is easier to break than C-Br bond OR less energy is needed to break the C-I bond ✓	1	Answer must refer to the correct bond ALLOW ora IGNORE references to electronegativity
	(c)	$\text{HCl} + \text{CH}_3\text{CHCHCH}_3 \rightarrow \text{CH}_3\text{CH}_2\text{CHC}/\text{CH}_3$ Correct structural formula of product ✓ Equation with structural formulae ✓	2	Must use structural formulae for both organic compounds in the equation ALLOW $\text{CH}_3\text{CH}=\text{CHCH}_3$ for but-2-ene ALLOW two marks for correct equation with structural formulae ALLOW one mark for correct equation with displayed formulae IGNORE any mechanisms
	(d)	HCFCs OR hydrocarbons OR HFCs ✓	1	ALLOW alkanes DO NOT ALLOW specific alkanes
Total			10	