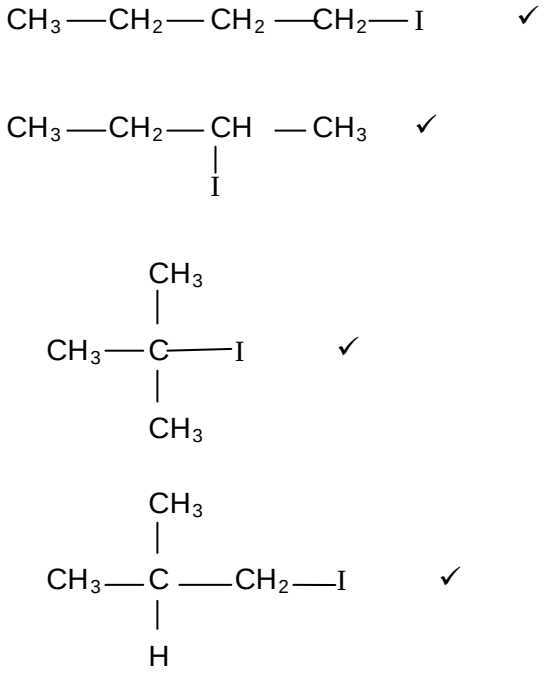
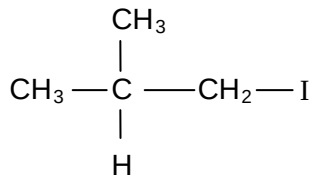
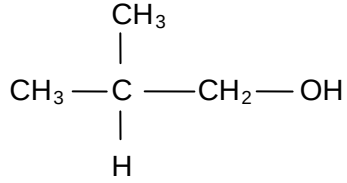
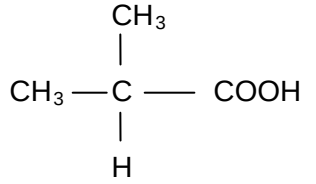
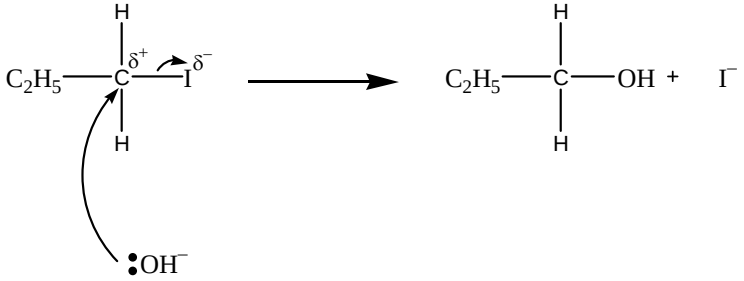
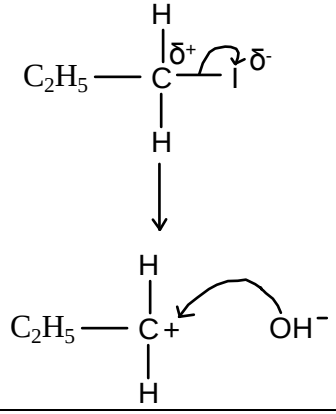
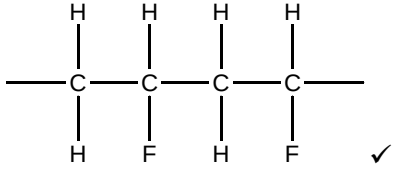
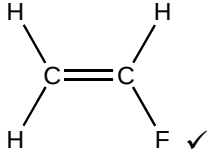
Question			Answer	Marks	Guidance
1	(a)		1-bromopentane reacts faster **OR** 1-chloropentane reacts slower ✓ C–C*l* stronger bond (than C–Br bond) **OR** C–C*l* shorter bond (than C–Br bond) **OR** C–C*l* bond is harder to break **OR** needs more energy to break C–C*l* bond **OR** bond enthalpy of C–C*l* greater (than C–Br bond) ✓	2	**ALLOW** takes more time to react **ALLOW** chloro compound reacts slower than bromine compound **DO NOT ALLOW** bromine reacts faster than chlorine **ALLOW** ORA Answer must refer to the C–C*l* bond or C–Br bonds
	(b)	(i)	 ✓ ✓ ✓	4	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) n.b. C_2H_5 is unambiguous but C_3H_7 is ambiguous **IGNORE** incorrect name Mark incorrect answers first of all. • One incorrect answers maximum 3 marks • Two incorrect answers maximum 2 marks • Three incorrect answers maximum 1 mark • Four incorrect answers scores 0 mark **ALLOW** as a slip one stick with no H on in a displayed formula

Question			er	Marks	Guidance
	(b)	(ii)	$C_4H_{10}O$ ✓	1	**IGNORE** any structures drawn **DO NOT ALLOW** C_4H_9OH

Question			er	Marks	Guidance
	(b)	(iii)	**infrared** 1700–1730 cm^{-1} indicates carbonyl group ✓ broad 2900 cm^{-1} indicates O–H bond **AND** it is a **carboxylic acid** ✓ **explanation mark** **B** has a branched structure because of relationship to methylpropene **OR** **C** has a branched structure because of relationship to methylpropene **OR** **C** must be a primary alcohol because it is oxidised to a carboxylic acid **OR** a primary alcohol because it reacts with acidified dichromate to make a carboxylic acid **OR** **C** cannot be a tertiary alcohol because it is oxidised **OR** cannot be a tertiary alcohol because it does react with acidified dichromate ✓	6	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** **LOOK ON THE SPECTRUM** for labeled absorbances which can be given credit **ALLOW** has a C=O bond because it has absorbance within range 1640–1750 cm^{-1} **ALLOW** 2900 cm^{-1} indicates O–H in carboxylic acid **ALLOW** has O–H bond in carboxylic aid because it has absorbance within range 2500–3300 cm^{-1} The presence of carboxylic acid can be anywhere in the text including the structure for **D** If two marking points from the explanation mark are given both must be correct

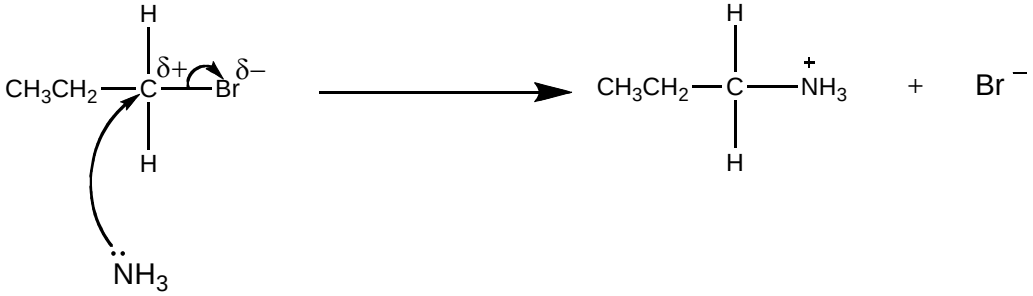
Question			er	Marks	Guidance
			B is  ✓		**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous)
			C is  ✓		**IGNORE** incorrect names for **B**, **C** and **D**
			D is  ✓		Mark correct branched structures first of all. If there are no correct branched structures and **C** is $CH_3CH_2CH_2CH_2OH$ then **ALLOW** one mark for $CH_3CH_2CH_2COOH$ and one mark for $CH_3CH_2CH_2CH_2I$
			Total	**13**	

Question			Expected Answers	Marks	Additional Guidance
2	(a)	(i)	 C–I curly arrow from the bond not from carbon atom ✓ curly arrow from the OH^- ✓ correct partial charges on C—I ✓	3	no need to show any lone pairs on oxygen but must have a clear negative sign rather than partial negative charge **IGNORE** lone pairs **IGNORE** products of this reaction **ALLOW** curly arrow from a negative charge or from any part of hydroxide ion If S_N1 mechanism is given then use the mark scheme below correct partial charges on C—I ✓ C–I curly arrow from the bond not from carbon atom ✓ curly arrow from the OH^- to the **correct** carbocation ✓ 
		(ii)	nucleophilic substitution ✓	1	
	(b)		C–I bonds broken more easily ✓ C–I bonds are weaker **OR** have less bond enthalpy **OR** C–I bonds are longer ✓	2	**ALLOW** ora e.g. C—Br bonds are stronger **OR** broken less easily

Question			Expected Answers	Marks	Additional Guidance
	(c)		**Any TWO from:** CFCs take many years to reach the ozone layer **OR** long residence time ✓ CFCs are still being used ✓ there are other ozone depleting substances ✓	**2**	 **IGNORE** because chlorine radicals stay in the stratosphere **ALLOW** other named ozone depleting substances e.g. NO and HFCs
	(d)	**(i)**	 ✓	**1**	Free bonds at bond ends must be present **ALLOW** minor slip e.g. missing one hydrogen and left as a stick **ALLOW** more than two repeat units but must be a whole number of repeat units **IGNORE** brackets, use of numbers and n in the drawn structure
		(ii)	 ✓	**1**	**ALLOW** skeletal formula **ALLOW** CH_2CHF
	(e)		**Any two from:** separation into types and recycling **OR** sort plastics, melt and remould ✓ combustion for energy generation ✓ used for cracking **OR** feedstock for plastics or chemicals ✓	**2**	**IGNORE** biodegradable used as a fuel is insufficient releases energy is insufficient **ALLOW** burning plastics to release energy **ALLOW** organic feedstock / raw materials to make organic compounds
			Total	**12**	

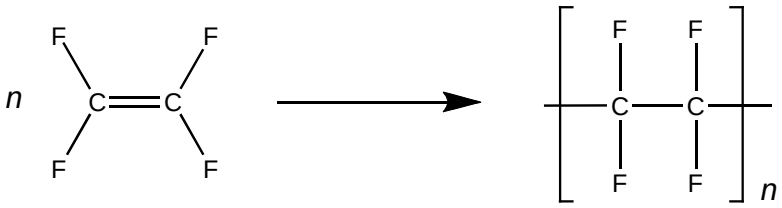
Question			er	Marks	Guidance
3	(a)		Shape – tetrahedral ✓ Bond angle 109.5^{o} ✓	2	 **ALLOW** 109–110^{o}
	(b)	(	Volatile **OR** non-toxic **OR** non-flammable **OR** easily vaporised ✓	1	**ALLOW** not carcinogenic / not an irritant / not harmful / not hazardous **IGNORE** cheap / not dangerous / gas / low boiling point **DO NOT ALLOW** inflammable
		(ii)	(C–F or C–C*l*) bonds need a large amount of energy to break ✓	1	**ALLOW (**the C–F or C–C*l*) bonds are strong / bonds have a large bond enthalpy **ALLOW** the molecule is not polar enough / non-polar molecule is **not** sufficient **ALLOW** the activation energy is too high **DO NOT ALLOW dissolves** **IGNORE** references to hydrogen bonding
	(c)		$CF_2Cl_2 \rightarrow CF_2Cl + Cl$ ✓ **AND ANY TWO FROM** C*l* catalyses the decomposition of ozone ✓ $Cl + O_3 \rightarrow ClO + O_2$ ✓ $ClO + O \rightarrow Cl + O_2$ ✓	3	**ALLOW** CF_2Cl_2 (breaks down to) produces **chlorine** atoms/radicals **ALLOW** equation with any CFC **ALLOW** $ClO + O_3 \rightarrow Cl + 2O_2$ **ALLOW** $O_3 + O \rightarrow 2O_2$ **OR** $3O_2 \rightarrow 2O_3$ for one mark if the two equations for the steps have not been given **IGNORE** other propagation equations

Question			er	Marks	Guidance
	(d)		Because (more) UV will reach the Earth's surface **and** risk of (skin) cancer increased/risk of cataracts/crop mutation increased ✓	1	**DO NOT ALLOW** global warming **ALLOW** protects from UV which causes skin cancer etc
	(e)		***Ideas related to uses*** CFCs are still entering the atmosphere (from disused items) **OR** CFCs are still used (for some purposes and by some countries) ✓ ***Ideas relating to lifetime within the atmosphere*** CFCs have a long lifetime in the atmosphere **OR** it takes a long time for CFCs to reach upper atmosphere **OR** CFCs are inert ✓	2	**ALLOW** 'stratosphere' for 'upper atmosphere' **ALLOW** CFCs are still entering the ozone layer
			Total	**10**	

Question			Answer	Mark	Guidance
4	(a)	(i)	$CH_3CH_2I + 2NH_3 \rightarrow CH_3CH_2NH_2 + NH_4I$ correct reactants ✓ correct products and balanced ✓	2	**ALLOW** $CH_3CH_2I + NH_3 \rightarrow CH_3CH_2NH_2 + HI$ **ALLOW** $CH_3CH_2I + NH_3 \rightarrow CH_3CH_2NH_3I$
		(ii)	 Correct curly arrow from the lone pair of ammonia to the carbon atom of C–Br ✓ Correct dipole on $C^{\delta+}$–$Br^{\delta-}$ bond **and** curly arrow showing the heterolytic fission of the C–Br bond ✓ Correct missing product: Br^- ✓	3	Curly arrow **must** start from the lone pair on nitrogen and go to the carbon atom **DO NOT ALLOW** NH_3^- **OR** $^-NH_3$ **ALLOW** δ– on the N atom of NH_3 Curly arrow must start from the bond and go to the Br

Question			Answer	Mark	Guidance
	(b)		***Effect of halogen in RX (3 marks)*** Any correct comparison of rate **OR** reaction time between at least **TWO** of chloroalkane, bromoalkane and iodoalkane ✓		**ANNOTATE WITH TICKS AND CROSSES** ***Examples*** chloroalkane reacts the slowest iodo compound reacts the fastest C–I bond is hydrolysed faster than C–Br C–Br has shorter reaction time than C–Cl **DO NOT ALLOW** references to halogens as elements: *ie* chlorine is less reactive than bromine than iodine **DO NOT ALLOW** chloride, bromide and iodide
			Bond strength **OR** bond enthalpy/bond energy mentioned anywhere as a factor (even if reasoning is incorrect) ✓		**ALLOW** this mark if mentioned within effect of halogen, branching **OR** temperature
			Any correct comparison of bond strength **OR** bond enthalpy/energy **OR** bond length **OR** ease of breaking of at least **TWO** of C–Cl, C–Br and C–I ✓		***Examples*** C–I bond is weaker than C–Br bond C–I bond is the weakest C–Cl bond is shorter than C–I bond C–Cl is strongest bond C–Br is broken more easily than C–Cl

Question			Answer	Mark	Guidance
	(b)		***Effect of branching (2 marks)*** Any correct comparison of rate or reaction time between at least **TWO** of the bromoalkanes ✓ A sensible comparison of bond strength **OR** bond enthalpy/energy **OR** bond length **OR** ease of breaking of the C–Br bond in at least **TWO** of the bromoalkanes ✓ ***Effect of temperature (2 marks)*** **QWC** – Use of 50 ºC and 60 ºC using information in the table to show that rate increases with temperature ✓ At higher temperature, particles have more energy **OR** At higher temperature, particles move faster ✓	7	Tertiary hydrolyses faster than secondary **OR** reaction time is less with tertiary than primary **OR** secondary hydrolyses faster than primary **OR** branched hydrolyses faster than straight chains **OR** primary hydrolyses the slowest **OR** tertiary hydrolyses the fastest **OR** when halogen on carbon 1 is hydrolysed slower than when halogen is on carbon 2 ✓ **DO NOT ALLOW** short chains hydrolyse faster than long chains ***Examples*** C—Hal is weaker in tertiary halogenoalkane **OR** C—Br bond is stronger when it is bonded to carbon 1 rather than carbon 2 **ALLOW** an explanation based on relative stabilities of tertiary, secondary and/or primary carbocations Answer must **quote evidence** from the table to get this mark Rate increases with temperature is **NOT** sufficient **ALLOW** more energy available to break the C–Hal bond **OR** more energy vibrates the C–Hal more so bond can break more easily **ALLOW** more successful collisions at higher temperature **ALLOW** more molecules exceed activation energy **ALLOW ORA**

Question			Answer	Mark	Guidance
	(c)	(i)	 Correct monomer ✓		
			Correct polymer ✓		Polymer must have **side** links (do not have to cut through bracket) **ALLOW a correct section of the polymer with side links** **ALLOW ECF** from wrong monomer, including use of Fl for F
			Balanced equation – correct use of *n* in the equation ✓	3	*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) On the LHS, **DO NOT ALLOW** $(C_2F_4)_n$ (the *n* must be in front of the monomer) nC_2F_4 → $-(-C_2F_4-)_n-$ scores 1 mark for the correct use of *n*
		(ii)	(PVC) produces hydrogen chloride **OR** produces acidic gases **OR** (PVC) produces phosgene **OR** produces toxic gases **OR** (PVC) produces dioxins ✓	1	**ALLOW** produces poisonous gases **OR** produces gases that can kill **IGNORE** HF, Cl_2 and F_2 Makes a dangerous or harmful gas is **NOT** sufficient **IGNORE** CO and CO_2 are greenhouse gases **IGNORE** chlorine radicals and ozone depletion **IGNORE** causes pollution
			Total	**16**	