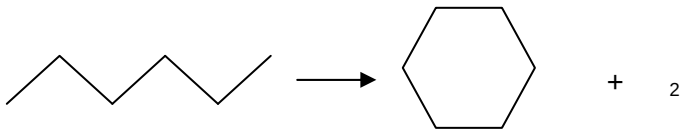
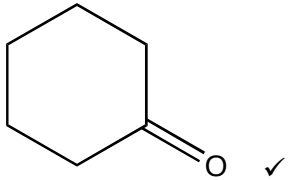
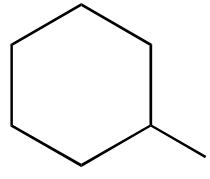
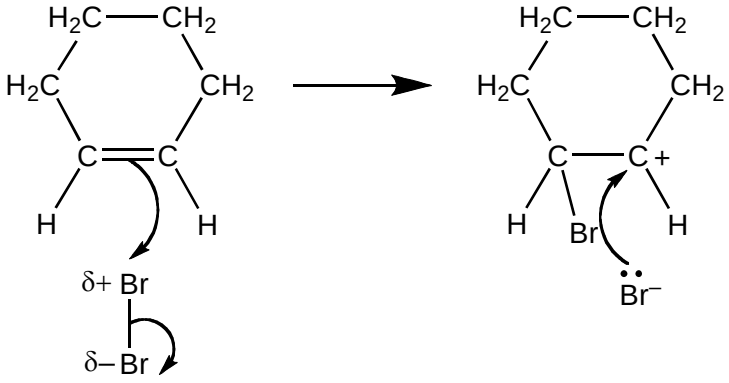
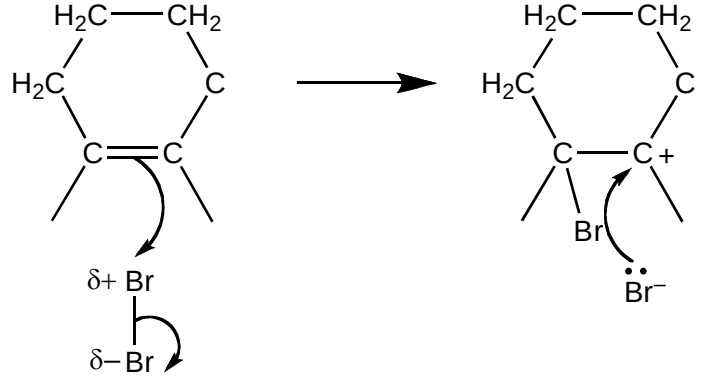
Question			Answer	Mark	Guidance
1	(a)		(The hydrocarbons have) different boiling points ✓ The larger the molecules the stronger the van der Waals' forces ✓	2	**PLEASE READ COMMENT ON PAGE 3** **ALLOW** longer chains have higher boiling points **OR** separation based on boiling point **OR** condense at different temperatures **ALLOW** the larger molecular size more van der Waals' forces **OR** longer chains have stronger van der Waals' force **OR** the more electrons, the stronger the van der Waals' forces **OR** the more surface contact the more van der Waals' forces **IGNORE** surface area **ALLOW ORA** van der Waals must be seen at least once in correct context **ALLOW** any 'recognisable' spelling of van der Waals', use of VDW is **not** sufficient **DO NOT ALLOW** intermolecular force unless qualified as van der Waals' somewhere
	(b)	(i)	C_nH_{2n} ✓	1	
		(ii)	$C_6H_{14} \rightarrow C_6H_{12} + H_2$ ✓	1	**ALLOW** displayed, skeletal or structural formulae or combination in the equation 

Question			Answer	Mark	Guidance
	(b)	(iii)	cyclohexane has more efficient combustion ✓	1	Assume comments refer to cyclohexane unless specified otherwise **ALLOW** cyclohexane allows smoother burning **OR** cyclohexane increases octane number **OR** cyclohexane reduces knocking **OR** cyclohexane is less likely to produce pre-ignition **OR** cyclohexane is a more efficient fuel **OR** cyclohexane burns better **OR** easier to burn **OR** cyclohexane combusts more easily **OR** improves combustion **DO NOT ALLOW** cyclohexane ignites more easily **ALLOW** ORA for hexane **IGNORE** cyclohexane increases volatility of fuel **IGNORE** cyclohexane has a lower boiling point cyclohexane is a better fuel on its own is **NOT** sufficient cyclohexane burns more cleanly on its own is **NOT** sufficient
	(c)	(i)	*Unsaturated:* Contains (at least one) **carbon–carbon** double bond **OR** C=C **OR** multiple carbon–carbon bond ✓ *hydrocarbon*: Contains hydrogen and carbon **only** ✓	2	**DO NOT ALLOW** just 'contains a double bond' **DO NOT ALLOW** 'a mixture of carbon and hydrogen' **OR** 'contains carbon and hydrogen' **OR** carbon and hydrogen molecules only
		(ii)	More than one hydrogen atom is substituted **OR** 'multisubstitution' (by chlorine) **OR** further substitution occurs ✓	1	**ALLOW** can get dichloro-compounds (**IGNORE** numbering) **ALLOW** reaction forms more than one **organic** product **DO NOT ALLOW** 'forms termination products' on its own Reaction is not specific **OR** reaction is difficult to control is **NOT** sufficient

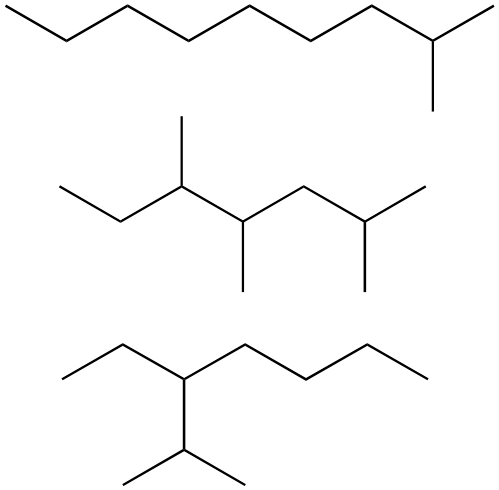
Question			Answer	Mark	Guidance
	(c)	(iii)	Contains a lone pair that can be donated ✓	1	**ALLOW** it can donate an electron pair 'lone pair' on its own is **NOT** sufficient
		(iv)	**A**  ✓  **B** Br ✓	2	**ALLOW** skeletal, displayed or structural formulae for **A** and **B** **ALLOW** combination of types of formulae as long as it is unambiguous **DO NOT ALLOW** molecular formula For **A**, **ALLOW** carbonyl group on any carbon atom as it is still cyclohexanone For **B**, **ALLOW** bromine atom on any carbon atom as it is still bromocyclohexane

Question			Answer	Mark	Guidance
	(c)	(v)	Correct dipole on Br_2 / correct partial charges on Br_2 ✓ Correct curly arrow from double bond to attack bromine atom and correct curly arrow to show heterolytic fission of Br–Br ✓ Correct carbocation / carbonium ion drawn with the **full** positive charge shown: C^+ ✓ Correct curly arrow from lone pair of Br^- to correct carbon atom **OR** correct curly arrow from negative charge of Br^- to correct carbon atom ✓  	4	**ANNOTATE WITH TICKS AND CROSSES** Curly arrow must come from covalent bonds and not atoms **DO NOT ALLOW** $C^{\delta+}$ for charge on carbonium ion Curly arrow from bromide ion can come from the negative charge or the lone pair **DO NOT ALLOW** $Br^{\delta-}$ instead of Br^- Lone pair does not need to be shown on Br^- or used in mechanism Treat missing hydrogens on the CH_2 as a slip Treat missing hydrogens on the double bond or carbonium ion as a slip providing a bond is shown ie  **ALLOW** use of skeletal formulae in mechanism
			Total	**15**	

Question			Answer	Mark	Guidance
2	(a)		**ANY THREE FROM** $C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_5OH$ ✓ Use of yeast/zymase at 25–45 ºC **OR** warm with yeast/zymase ✓ Anaerobic **OR** lack of oxygen ✓ (Separate bioethanol) by (fractional) distillation ✓	3	**IGNORE** state symbols **ALLOW** correct multiples **DO NOT ALLOW** yeast/zymase and heat **DO NOT ALLOW** yeast/zymase and reflux
	(b)	**(i)**	$C_{15}H_{30}O_2 + 21½O_2 \rightarrow 15CO_2 + 15H_2O$ ✓✓	2	**ALLOW** $\frac{43}{2}$ for 21½ **DO NOT ALLOW** [O] **ALLOW** one mark for correct products if equation is wrong
		(ii)	(Energy needed) for processing biofuel makes carbon dioxide ✓	1	**ALLOW** (energy needed) for transport makes carbon dioxide
	(c)		**ANY THREE FROM** Fossil fuels are finite resources **OR** biofuels are renewable ✓ Allows fossil fuels to be used as a feedstock for organic compounds ✓ Less food crops may be grown **OR** Land not used to grow food crops ✓ (rain) forests have to be cut down to provide land **OR** deforestation ✓ Shortage of fertile soils **OR** reduces fertility of soils ✓ No risk of large scale pollution from exploitation of fossil fuels ✓	3	**ANNOTATE WITH TICKS AND CROSSES** **ALLOW** fossil fuels are non-renewable **OR** plants are a renewable resource **OR** bio-fuels is (more) sustainable **OR** fossil fuels are not sustainable **ALLOW** decrease the need for fossil fuels Destroys habitats is **NOT** sufficient **IGNORE** comments about availability / fertilisers / pesticides

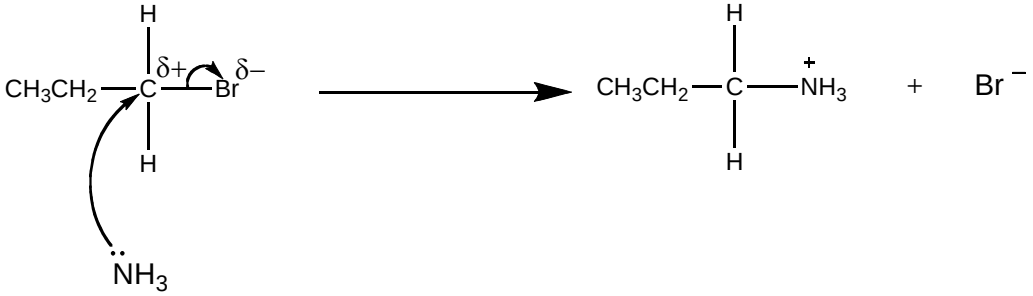
Question			Answer	Mark	Guidance
	(d)		React with hydrogen **OR** hydrogenation ✓ Nickel catalyst ✓	2	**IGNORE** reference to pressure and temperature
	(e)	**(i)**	Drawing of the *Z* isomer with the double bond shown in full ✓	1	Diagram must show a minimum of four carbon atoms and two hydrogen atoms and the correct orientation of the C=C double bond **ALLOW** minor slips with rest of structure eg missing atoms, bonds and subscripts
		(ii)	Double bond does not rotate **OR** restricted rotation of the double bond ✓ Each carbon atom of double bond is bonded to (two) different groups ✓	2	**ALLOW** π/pi bond does not rotate **IGNORE** 'bond does not move' **ALLOW** each carbon atom of double bond is bonded to (two) different atoms **OR** each carbon atom of double bond is bonded to a hydrogen and a carbon/different group **OR** each end of the π/pi-bond is bonded to different groups or atoms
			Total	**12**	

Question			Expected Answers	Marks	Additional Guidance
3	(a)		Fractional distillation ✓ Because fractions have different boiling points ✓	2	**DO NOT ALLOW** just 'distillation' For fractions, **ALLOW** components **OR** hydrocarbons **OR** compounds **ALLOW** condense at different temperatures **ALLOW** because van der Waals' forces differ between molecules **IGNORE** reference to melting points **IGNORE '**crude oil' **OR** 'mixture' has different boiling points' ……. **but ALLOW** 'separates crude oil by boiling points
	(b)	(i)	Decane ✓	1	**DO NOT ALLOW** deceane
		(ii)	Skeletal formula of branched $C_{10}H_{22}$ ✓	1	Formula **must** be skeletal **AND** must not include any symbol, e.g. CH_3 Any possible skeletal formulae e.g.

Question			Expected Answers	Marks	Additional Guidance
					
		(iii)	Decane has more surface contact **OR** branched chains have less surface contact ✓ Decane has more van der Waals' forces **OR** branched chains have fewer van der Waals' forces ✓	**2**	**Both answers need to be comparisons** Assume 'it' refers to decane **IGNORE** surface area **ALLOW** straight chains can get closer together **OR** branched chains cannot get as close to one another **IGNORE** branched chain are more compact **ALLOW** Decane has stronger van der Waals' forces **OR** branched chains have weaker van der Waals' forces More intermolecular forces is **not** sufficient
		(iv)	Branched chains have more efficient combustion **OR** decane has less efficient combustion ✓	**1**	**ALLOW** branched chains are easier to burn **OR** easier to combust **OR** burn better **OR** more efficient fuel **OR** less likely to produce pre-ignition or knocking **OR** increases octane rating **ALLOW** ORA for decane

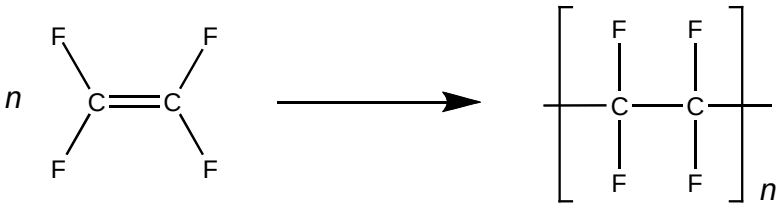
Question			Expected Answers	Marks	Additional Guidance
					Better fuel is **NOT** sufficient Burns more cleanly is **NOT** sufficient
	(c)	**(i)**	$C_{10}H_{22} + 15½O_2 \longrightarrow 10CO_2 + 11H_2O$ All **four** species correct ✓ balancing of four correct species ✓	**2**	**ALLOW** any correct multiple **IGNORE** state symbols
		(ii)	$N_2 + O_2 \longrightarrow 2NO$ ✓	**1**	**ALLOW** any correct multiple including fractions **IGNORE** state symbols The mark is for the equation **IGNORE** writing

Question			Expected Answers	Marks	Additional Guidance
	(d)	**(i)**	Species with an unpaired electron ✓	**1**	**ALLOW** atom, molecule or particle with an unpaired electron **ALLOW** 'has an unpaired electron' **ALLOW** particle formed by homolytic fission **DO NOT ALLOW** particle with a single electron **OR** particle with a free electron
		(ii)	catalyst ✓	**1**	
		(iii)	$O + O_2 \longrightarrow O_3$ **OR** O reacts with O_2 to make ozone **OR** the reaction is reversible ✓ Rate of formation of ozone is the same as rate of decomposition ✓	**2**	**ALLOW** $O_2 + O \rightleftharpoons O_3$ **OR** $O_3 \rightleftharpoons O_2 + O$ ✓✓ **ALLOW** is in equilibrium **OR** $\rightleftharpoons$ in **correct** equation **OR** has steady state condition ✓ **IGNORE** other equations involving ozone
		(iv)	absorbs (harmful) UV ✓	**1**	**ALLOW** 'keeps out UV' **OR** 'filters UV' **ALLOW** increased UV could cause skin cancer **OR** increased UV could cause cataracts **OR** increased UV could cause mutation of crops ✓ **IGNORE** gamma
			Total	**15**	

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**	