

- M1.** (a) (base) elimination  
(penalise other words before 'elimination' e.g. nucleophilic) 1
- M1:** curly arrow from lone pair of electrons on oxygen of hydroxide ion  
(insist on a lone pair of electrons on the oxygen atom and a negative charge, but only credit this mark if the attack is to a correct H atom) 1
- M2:** curly arrow from the middle of the C-H bond to the middle of the C-C bond 1
- (only credit this mark if the arrow originates from the correct C-H bond and if an attempt has been made at M1)
- M3:** curly arrow from the middle of the C-Br bond towards/alongside the Br atom
- (credit M3 independently unless the bond breaking is contradicted by an additional arrow)  
(penalise curly arrow if the C-Br has a formal positive charge)  
(credit full marks for an E1 mechanism, with M2 awarded for a correct curly arrow on the correct carbocation)  
(award a maximum of two marks for either an incorrect haloalkane or an incorrect organic product)  
(maximum 2 marks for use of 'sticks' for the haloalkane, unless RE from 2(b), when credit can be given)
- (b) (i) **M1:** compounds with the same structural formula 1
- M2:** but the bonds/groups/atoms have different spatial arrangements or orientation or configuration/are arranged differently in space/3D  
(ignore reference to the same molecular formula for M1) 1
- (ii) **M1:** correct structural representation for cis-but-2-ene and its name or its identification as the cis isomer 1
- M2:** correct structural representation for trans-but-2-ene and its name or its identification as the trans isomer  
(accept representations which are 90° to linear)

(award one mark for two correct structures but either wrong/no names)

(maximum 1 mark for an incorrect alkene)

1

(iii) geometric(al) or cis-trans

1

(c) nucleophile or electron pair donor  
(penalise 'base')

1

(d)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br} + 2\text{NH}_3 \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2 + \text{NH}_4\text{Br}$

(M1 correct product)

(M2 balanced equation using  $2\text{NH}_3$  and leading to  $\text{NH}_4\text{Br}$ )

(penalise M1 for use of  $\text{C}_4\text{H}_9\text{NH}_2$  or for incorrect haloalkane, but allow consequent correct balancing of equation with 2 moles of ammonia)

2

(1-)butylamine

(credit 1-aminobutane and butyl-1-amine)

(award QoL mark for correct spelling)

1

[13]

**M2.** (a)  $\text{F}_2 \rightarrow 2\text{F}\cdot$

1

$\text{CH}_4 + \text{F}\cdot \rightarrow \cdot\text{CH}_3 + \text{HF}$

1

$\cdot\text{CH}_3 + \text{F}_2 \rightarrow \text{CH}_3\text{F} + \text{F}\cdot$

1

$\cdot\text{CH}_3 + \text{F}\cdot \rightarrow \text{CH}_3\text{F}$

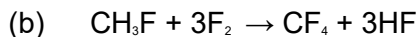
1

OR  $2\cdot\text{CH}_3 \rightarrow \text{C}_2\text{H}_6$

(allow credit on this occasion for  $2\text{F}\cdot \rightarrow \text{F}_2$ )

(penalise incorrect symbol  $\text{F}$ , once only)

(penalise absence of radical dot once only)



1

[5]

**M3.** (a) (i) (Free) radical substitution  
(Both words needed)

1

(ii) M1 initiation ONLY

1

M2 ultra-violet light OR sunlight OR  $1000^\circ\text{C} \geq T \geq 450^\circ\text{C}$   
(Ignore reference to temperature if included with uv light)  
(Penalise "high temperature" for M2)

1

(iii)  $2\dot{\text{C}}\text{H}_3 \rightarrow \text{C}_2\text{H}_6$   
(OR  $\text{CH}_3\text{CH}_3$  as alternative to  $\text{C}_2\text{H}_6$ )

1

(iv)  $\text{CH}_3\text{Br} + \text{Br}_2 \rightarrow \text{CH}_2\text{Br}_2 + \text{HBr}$

1

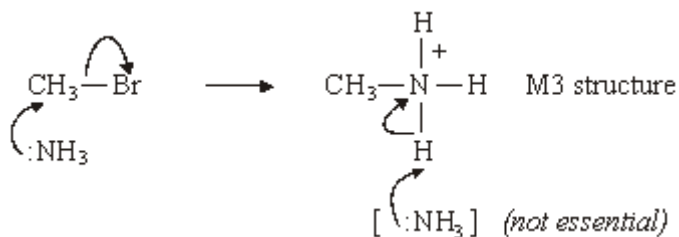
(b) (i) Electron pair donor  
OR species with an electron pair able to form a covalent bond.

1

(ii) Methylamine  
(Credit "aminomethane")

1

(iii)



1

- M1 arrow to show breakage of C – Br bond 1
- M2 arrow from lone pair on N of NH<sub>3</sub> to form bond with C 1
- M4 arrow from bond of N – H to N atom of CH<sub>3</sub> $\overset{+}{N}$ H<sub>3</sub>  
*(Ignore partial charges on haloalkane but penalise if incorrect)*  
*(Accept CH<sub>3</sub> $\overset{+}{N}$ H<sub>3</sub> for M3)*  
*(Full credit for carbocation mechanism; M1 for C – Br bond breakage and M2 for lone pair attack on carbocation)*  
*(Second mole of ammonia not essential to mechanism for full credit)* 1

[11]

- M4.** (a) (i) Electrophilic addition  
*(Both words required)* 1
- (ii) M1 the reaction to form 1-bromopropane goes via the primary carbocation OR 1° carbocation
- OR via CH<sub>3</sub>CH<sub>2</sub> $\overset{+}{C}$ H<sub>2</sub>
- M2 primary carbocations are less stable than secondary carbocations  
*(Credit converse arguments for M1 and M2 i.e. the reaction to form 2-bromopropane goes via the secondary carbocation, M1, and secondary carbocations are more stable than primary carbocations. M2)*  
*(Accept the use of “carbonium ions” as an alternative to carbocation)* 1
- (b) M1 NaOH OR KOH OR correct name 1
- M2 aqueous or solution in water *(ignore heat, reflux etc.)*

(Penalise M1 for hydroxide ion alone, but mark on and credit M2)

(Credit M2 ONLY for H<sub>2</sub>O as reagent and heat / warm / T=50 to 100°C)

(NaOH(aq) scores M1 and M2 provided it is not contradicted)

(Penalise M2 if NaOH(aq) followed by concentrated or ethanol)

(Penalise M1 and M2 if followed by acid)

1

- (c) Ethanolic OR alcoholic OR CH<sub>3</sub>CH<sub>2</sub>OH / CH<sub>3</sub>OH solvent OR aqueous ethanol/alcohol

OR higher temperature (must be comparative)

(Ignore heat or heat under reflux)

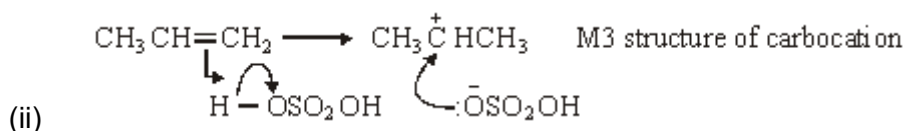
(Credit part (c) independently from part (b))

(Penalise "ethanoic")

1

- (d) (i) Secondary OR 2°

1



M1 arrow from double bond to H of H – O bond

M2 arrow from bond to oxygen atom to show H – O bond breakage

M4 arrow from lone pair of electrons to carbon atom of carbocation

(Penalise M1 if arrow goes to H<sub>2</sub>SO<sub>4</sub> or to formal positive charge on H, but ignore partial charges on sulphuric acid unless wrong)

(Credit M2 for H<sup>+</sup> ion)

(For M4, accept negative charge anywhere on the ion)

4

- (iii) Catalyst ONLY

(Ignore homogeneous, heterogeneous)

1

[12]

- M5. (a) (i) An appropriate alkene; CH<sub>3</sub>CH<sub>2</sub>CHCH<sub>2</sub> or (CH<sub>3</sub>)<sub>2</sub>CCH<sub>2</sub>

	1
Isomer 1	1
Isomer 2	1
Position isomerism	1
Mechanism	
electrophilic attack and electron shift to Br (Unless H <sup>+</sup> used)	1
carbocation	1
reaction with carbocation	
<i>[Allow mechanism marks for the alkene CH<sub>3</sub>CHCHCH<sub>3</sub>]</i>	
<i>[Allow one mark if mechanism for minor product given]</i>	1
(ii) An appropriate carbonyl; CH <sub>3</sub> CH <sub>2</sub> CHO	1
Mechanism nucleophilic attack and electron shift to O	1
anion intermediate	1
reaction with anion	
<i>[Allow mechanism marks for the carbonyl (CH<sub>3</sub>)<sub>2</sub>CO]</i>	1
Isomer 1	1
Isomer 2	1
Optical isomerism	
<i>NB Isomer structures must be tetrahedral</i>	
<i>NB Penalise "stick" structures once in part (a)</i>	1
(b) QoL	
Large charge on carbonyl carbon atom due to bonding to O and Cl	1

Nucleophiles have electron pairs which can be donated

1

Equation Species

1

Balanced

1

**[18]**