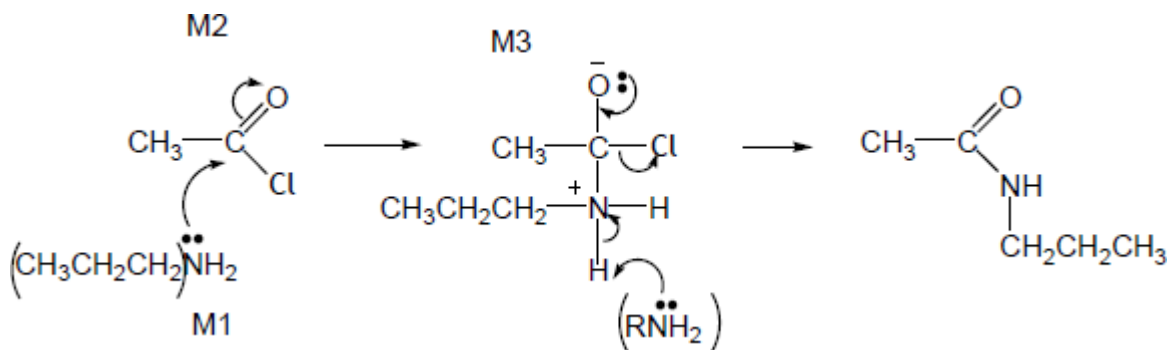


M1.(a) (nucleophilic) addition-elimination

1



Allow wrong amine in M1 but penalise in M3

Allow C<sub>3</sub>H<sub>7</sub> in M3

Minus sign on NH<sub>3</sub> loses M1 (but not M4 if NH<sub>3</sub> also shown here)

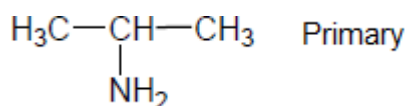
- Allow attack by: NH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub>
- M2 not allowed independent of M1, but allow M1 for correct attack on C<sup>+</sup>
- + rather than δ<sup>+</sup> on C=O loses M2
- If Cl lost with C=O breaking, max 1 for M1
- M3 for correct structure with charges but lone pair on O is part of M4
- 3 arrows in M4 can be shown in two separate steps.
- If M3 drawn twice, mark first answer eg ignore missing + if missed off second structure
- Only allow M4 after correct / very close M3
- For M4, ignore RNH<sub>2</sub> removing H<sup>+</sup> but lose M4 for Cl<sup>-</sup> removing H<sup>+</sup> in mechanism,
- but ignore HCl shown as a product.

4

N-propylethanamide must be this name even if wrong amine used  
NOT N-propylethaneamide

1

(b) (i)

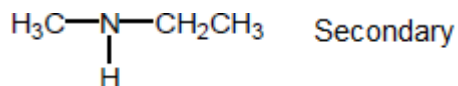


Not allow ambiguous C<sub>3</sub>H<sub>7</sub>NH<sub>2</sub>

BEWARE No mark for the original amine CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>NH<sub>2</sub>

*Label and structure must both be correct for each type to score the mark.*

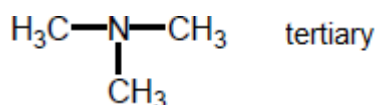
1



Allow C<sub>2</sub>H<sub>5</sub>

*Penalize wrong number of carbons but otherwise correct, first time only.*

1



1

(ii) Absorption at 3300–3500 (cm<sup>-1</sup>) in spectrum

*Allow trough, peak, spike.*

*Ignore absorption at 750 – 1100 for C–C bond in secondary - this is within fingerprint region.*

*Allow any number in this range.*

*If range missing, no further marks.*

*If range linked to tertiary, no further marks.*

1

N–H (bond) (only) present in secondary amine or not present in tertiary amine

**OR**

This peak or N–H absorption (only) present in spectrum of secondary amine or not present in spectrum of tertiary amine

1

(c) (i) M1 Route **A**: stage 1 KCN

*Apply list principle for extra reagents or catalysts  
NOT HCN NOT KCN / acid Not KCN / HCN*

1

M2 Aqueous or ethanolic

*M2 only scores after correct M1*

*ignore warm; acid here loses M1 & M2*

1

M3 Route **A** Intermediate  $\text{CH}_3\text{CH}_2\text{CN}$  or propanenitrile

*If M3 intermediate wrong, max 2 for M1 & M2 ie no mark for stage 2*

Name alone must be exactly correct to gain M1 but mark on if name close

*But if M3 intermediate close, eg "nitrile" or wrong nitrile, can award marks in stage 2*

correct formula gains M1 (ignore name if close)

*If stage 1 correct and intermediate is missing, can award marks in stage 2*

contradiction of name and formula loses mark

*stage 1 wrong & intermediate missing, no marks.*

1

M4 Route **A**: stage 2  $\text{H}_2$

H loses M4 but mark on

$\text{LiAlH}_4$

*Apply list principle for extra reagents or catalysts.*

*M5 only scores after correct M4*

*Not  $\text{NaBH}_4$ , not Sn or Fe / HCl*

*Allow (dil) acid after but not with  $\text{LiAlH}_4$*

*Penalise conc acid.*

1

M5 Ni or Pt or Pd

ether

1

M6 Route **B**  $\text{NH}_3$

*With acid loses M6 & M7*

*Apply list principle for extra reagents or catalysts.*

1

M7 Excess  $\text{NH}_3$

*Ignore conc, ignore high P, ignore solvent.*

1

(ii) Route **A** disadv HCN Toxic / poisonous KCN or cyanide or  $\text{CN}^-$  or

Expensive  $\text{LiAlH}_4$   
ignore acidified

**OR** lower yield because 2 steps

*Allow  $\text{H}_2$  flammable / explosive etc.*

*Not just dangerous.*

*Ignore time reasons.*

1

Route **B** disadv Further reaction / substitution likely  
*Allow impure product.*

1

[20]

**M2.(a)** Sn / HCl **OR** Fe / HCl not conc  $\text{H}_2\text{SO}_4$  nor any  $\text{HNO}_3$

Ignore subsequent use of NaOH

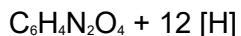
*Ignore reference to Sn as a catalyst with the acid*

*Allow  $\text{H}_2$  (Ni / Pt) but penalise wrong metal*

*But NOT  $\text{NaBH}_4$ ,  $\text{LiAlH}_4$ , Na /  $\text{C}_2\text{H}_5\text{OH}$*

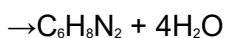
1

**Equation must use molecular formulae**



*12[H] and 4H<sub>2</sub>O without correct molecular formula scores 1 out of 2*

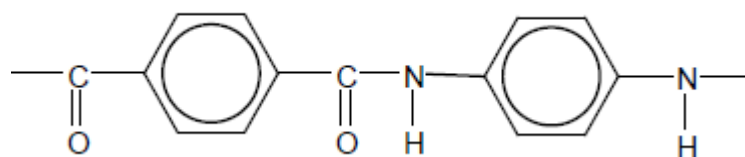
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*Allow .... + 6H<sub>2</sub> if H<sub>2</sub> / Ni used*

*Allow -CONH- or -COHN- or -C<sub>6</sub>H<sub>4</sub>-*

1



Mark two halves separately: lose 1 each for

- error in diamine part
- error in diacid part
- error in peptide link
- missing trailing bonds at one or both ends
- either or both of H or OH on ends

Ignore n

2

- (b)  $H_2$  (Ni / Pt) but penalise wrong metal  
*NOT Sn / HCl, NaBH<sub>4</sub> etc.*

1

CH<sub>2</sub>

1

In benzene 120°

1

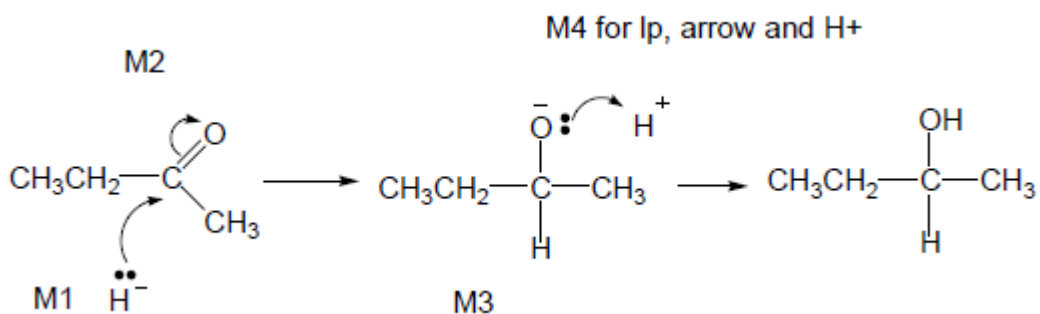
In cyclohexane 109° 28' or 109½°  
*Allow 108° - 110°*

If only one angle stated without correct qualification, no mark awarded

1

- (c) (i) Nucleophilic addition

1



- M2 not allowed independent of M1, but allow M1 for correct attack on C<sup>+</sup>
- + rather than δ<sup>+</sup> on C=O loses M2
- M3 is for correct structure including minus sign but lone pair is part of M4
- Allow C<sub>2</sub>H<sub>5</sub>
- M1 and M4 include lp and curly arrow
- Allow M4 arrow to H in H<sub>2</sub>O (ignore further arrows)

4

(ii) M1 Planar C=O (bond / group)  
Not just planar molecule

1

M2 Attack (equally likely) from either side  
Not just planar bond without reference to carbonyl

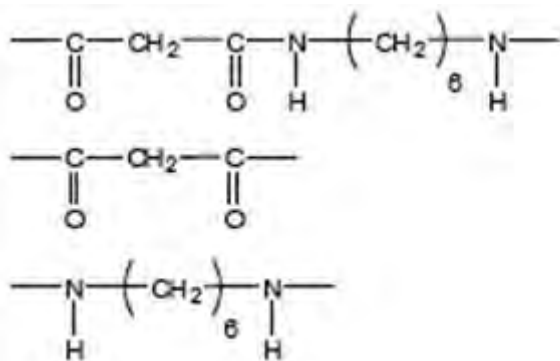
1

M3 (about product): Racemic mixture formed **OR** 50:50 mixture or each enantiomer equally likely

1

[17]

**M3.** (a) (i)



Allow -CONH- or -COHN-

Mark two halves separately

lose 1 each for missing trailing bonds at one or both ends or error in peptide link or either or both of H or OH on ends

1

Not allow  $-(C_6H_{12})-$

Ignore n

1

(ii) **M1** in polyamides - H bonding

1

**M2** in polyalkenes - van der Waals forces

Penalise forces between atoms or van der Waals bonds

1

**M3** Stronger forces (of attraction) in polyamides

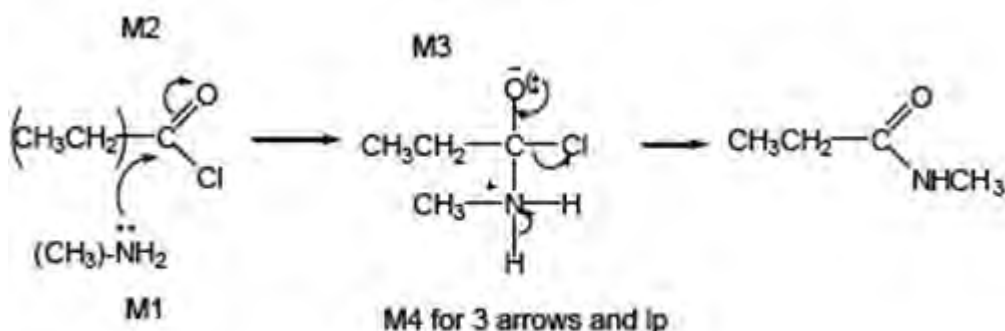
Or H bonding is stronger

(must be a comparison of correct forces to score M3)

Do not award if refer to stronger bonds

1

(b) (i) (nucleophilic) addition elimination



Not allow N-H<sub>2</sub>

Minus sign on  $\text{NH}_2$  loses **M1**

1

**M2** not allowed independent of **M1**, but allow **M1** for correct attack on  $\text{C}^+$

+ rather than  $\delta^+$  on  $\text{C}=\text{O}$  loses **M2**

If  $\text{Cl}$  lost with  $\text{C}=\text{O}$  breaking, max 1 for **M1**

**M3** for correct structure with charges but

lp on O is part of **M4**

only allow **M4** after correct/ very close **M3**

For **M4**, ignore  $\text{NH}_3$  removing  $\text{H}^+$  but lose

**M4** for  $\text{Cl}$  removing  $\text{H}^+$  in mechanism,

but ignore  $\text{HCl}$  as a product

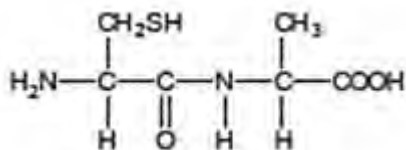
4

(ii) N-methylpropanamide

Not N-methylpropanamide

1

(c)



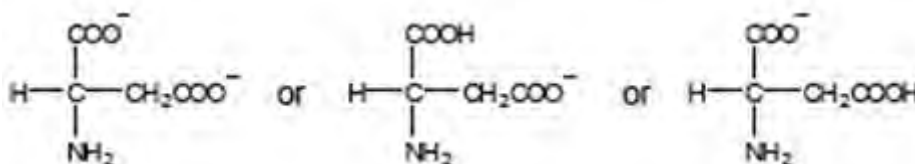
Allow  $-\text{CONH}-$  or  $-\text{COHN}-$

1

(d) (i) 2-amino-3-hydroxypropanoic acid

1

(ii)



Must be salts of aspartic acid

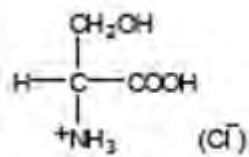
allow  $-\text{CO}_2^-$

allow  $\text{NH}_2-$

1

(iii) Penalise use of aspartic acid once in d(iii) and d(iv)





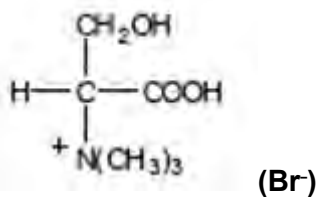
*allow  $-\text{CO}_2\text{H}$*

*allow  $\text{}^+\text{NH}_3-$*

*don't penalize position of + on  $\text{NH}_3$*

1

(iv) Penalise use of aspartic acid once in d(iii) and d(iv)



*allow  $-\text{CO}_2^-$*

*must show C-N bond*

*don't penalize position of + on  $\text{N}(\text{CH}_3)_3$*

1

[16]