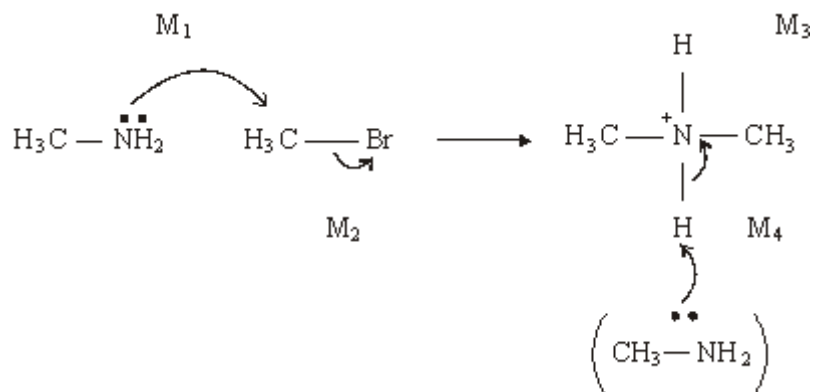


M1. (a) dimethylamine

1

(b) nucleophilic substitution

1



4

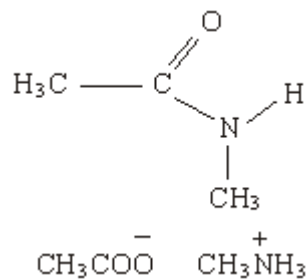
(c) quaternary ammonium salt

1

(cationic) surfactant / bactericide / detergent / fabric softener or conditioner/hair conditioner

1

(d)



(allow CH_3COOH or $\text{CH}_3\text{COO}^- \text{NH}_4^+$)

2

[10]

M2. X is CH₃CN or ethanenitrile or ethanonitrile or methyl cyanide or cyanomethane or ethyl nitrile or methanecarbonitrile

Not ethanitrile

but contradicton of name and structure lose marks

1

Y is CH₃CH₂NH₂ or ethylamine or aminoethane or ethanamine

1

Step 1: reagent KCN not HCN/HCl
 condition (aq)/alcohol - only allow condition if reagent correct or incomplete

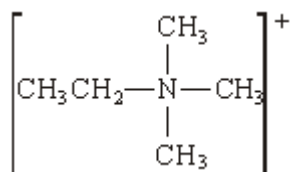
2

Step 2: reagent H₂ LiAlH₄ Na Zn/Fe/Sn Not NaBH₄
 condition Ni/Pt/Pd ether ethanol HCl

2

Z is an amine or aminoalkane or named amine even if incorrect name for Z secondary (only award if amine correct)

1



(Br⁻) + can be on N or outside brackets as shown

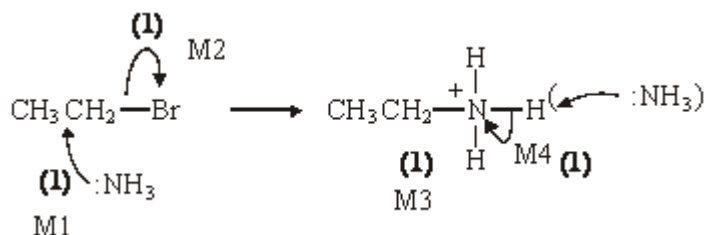
1

nucleophilic substitution

1

[9]

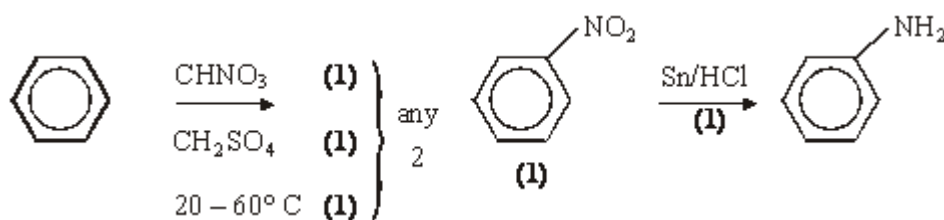
M3. (a)



Further reaction / substitution / formation of 2° / 3° amines etc (1)
use an excess of NH₃ (1)

6

(b)  repels nucleophiles (such as NH₃) (1)



5

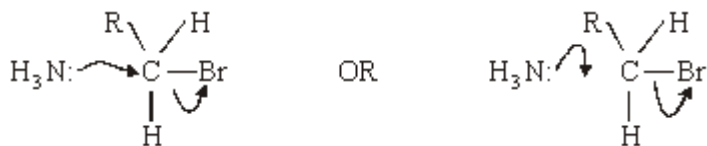
Notes

- (a) allow S_N1
penalise: Br⁻ instead of NH₃ removing H⁺ for M4
not contamination with *other amines* (this is in the question) not diamines
- (b) allow because NH₃ is a nucleophile or benzene is (only) attacked by electrophiles or C-Br bond (in bromobenzene) is stronger / less polar or Br lp delocalized
- HNO₃ / H₂SO₄ without either conc scores (1) allow 20 – 60° for (1) (any 2 ex 3)
- allow name or structure of nitrobenzene
- other reducing agents: Fe or Sn with HCl (conc or dil or neither)
not conc H₂SO₄ or conc HNO₃
allow Ni/H₂
Not NaBH₄ or LiAlH₄
- ignore wrong descriptions for reduction step e.g. hydrolysis or hydration

[11]

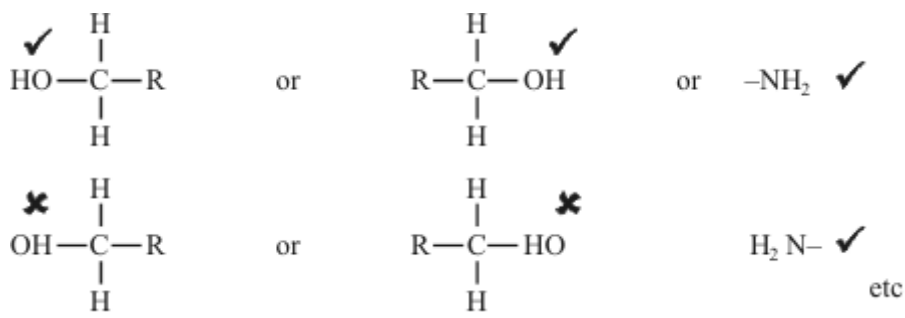
Organic points

- (1) Curly arrows: must show movement of a pair of electrons,
i.e. from bond to atom or from lp to atom / space
e.g.



(2) Structures

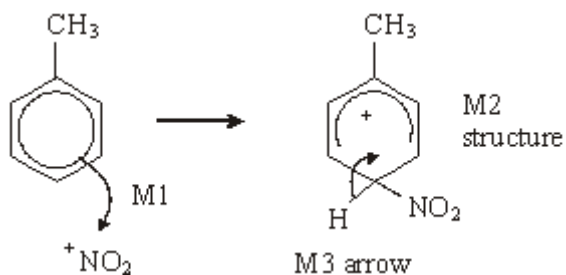
penalise sticks (i.e.) once per paper



Penalise once per paper

allow CH_3- or $-\text{CH}_3$ or $\begin{array}{c} \text{CH}_3 \\ | \end{array}$ or CH_3
or $\text{H}_3\text{C}-$

- M4.** (a) (i) conc HNO_3 1
- conc H_2SO_4
allow 1 for both acids if either conc missing 1
- $\text{HNO}_3 + 2\text{H}_2\text{SO}_4 \rightarrow \text{NO}_2^+ + \text{H}_3\text{O}^+ + 2\text{HSO}_4^-$
- or $\text{HNO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{NO}_2^+ + \text{H}_2\text{O} + \text{HSO}_4^-$ 1
- (iii) electrophilic substitution CH_3 1



horseshoe must not extend beyond C2 to C6 but can be smaller
 + must not be too close to Cl

3

- (b) Sn or Fe / HCl (conc or dil or neither)
 or Ni / H₂ not NaBH₄ LiAlH₄

1

- (c) (i) NH₃

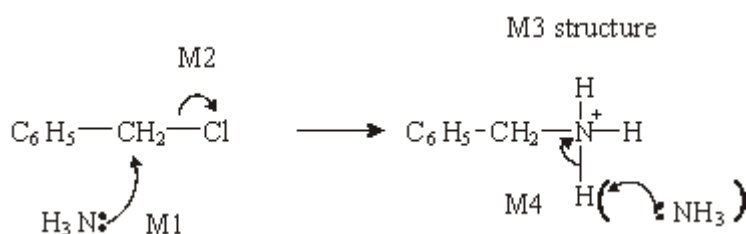
1

Use an excess of ammonia

1

- (ii) nucleophilic substitution

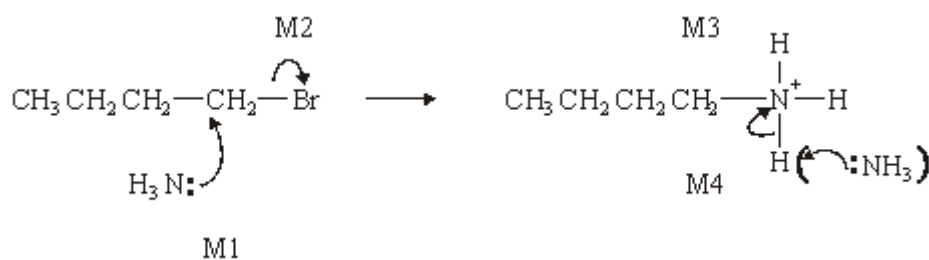
1



4

[15]

- M5.** (a) Nucleophilic substitution



1

M1, M2 and M4 for arrows, M3 for structure of cation

(Allow M2 alone first, i.e. SN1 formation of carbocation)

(Penalise M4 if Br⁻ used to remove H⁺)

- 4
- (b) Step 1 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CN}$ 1
- $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br} + \text{KCN} \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{CN} + \text{KBr}$ balanced 1
- (or CN^-) (or Br^-)
(not HCN) 1
- Step 2 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CN} + 2\text{H}_2 \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2$
(or $4[\text{H}]$) 1
- (c) (i) Lone pair (on N) (in correct context) 1
- R group increases electron density / donates electrons / pushes
electrons / has positive inductive effect 1
- (ii) Any strong acid (but not concentrated)
or any amine salt or ammonium salt of a strong acid 1
- (d) $\text{CH}_3\text{CH}_2\text{N}(\text{CH}_3)_2$ 1

[12]