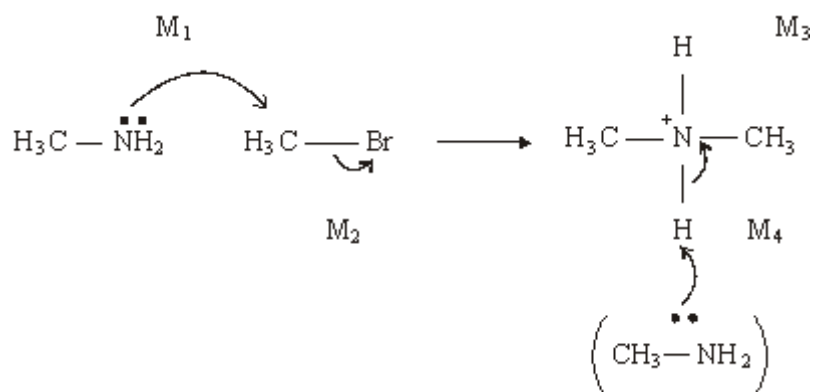


M1. (a) dimethylamine

1

(b) nucleophilic substitution

1



4

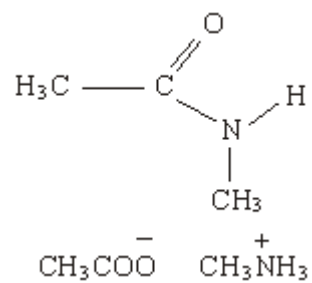
(c) quaternary ammonium salt

1

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

1

(d)



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

2

[10]

**M2.** X is CH<sub>3</sub>CN 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 CH<sub>3</sub>CH<sub>2</sub>NH<sub>2</sub> 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

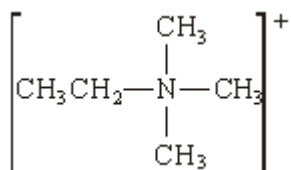
2

Step 2: reagent H<sub>2</sub> LiAlH<sub>4</sub> Na Zn/Fe/Sn Not NaBH<sub>4</sub>  
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<sup>-</sup>) + can be on N or outside brackets as shown

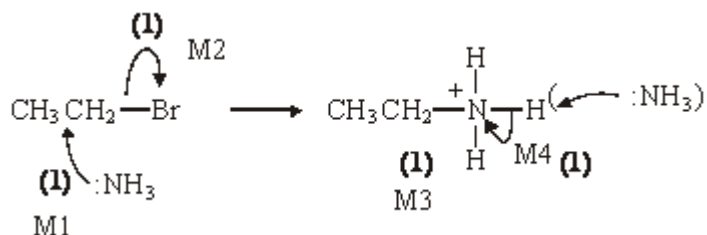
1

nucleophilic substitution

1

**M3.** (a)

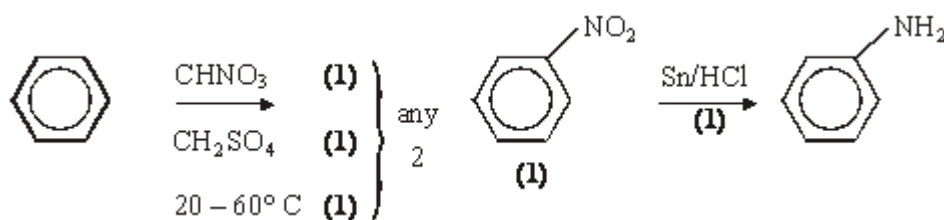
[9]



Further reaction / substitution / formation of 2° / 3° amines etc (1)  
use an excess of NH<sub>3</sub> (1)

6

(b)  repels nucleophiles (such as NH<sub>3</sub>) (1)



5

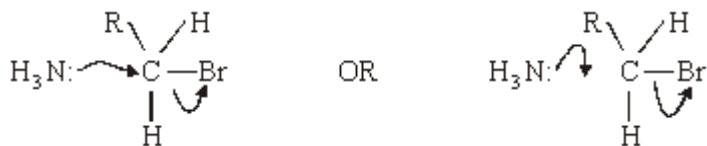
### Notes

- (a) allow S<sub>N</sub>1  
penalise: Br<sup>-</sup> instead of NH<sub>3</sub> removing H<sup>+</sup> for M4  
not contamination with *other amines* (this is in the question) not diamines
- (b) allow because NH<sub>3</sub> is a nucleophile or benzene is (only) attacked by electrophiles or C-Br bond (in bromobenzene) is stronger / less polar or Br lp delocalized
- HNO<sub>3</sub> / H<sub>2</sub>SO<sub>4</sub> 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 H<sub>2</sub>SO<sub>4</sub> or conc HNO<sub>3</sub>  
allow Ni/H<sub>2</sub>  
Not NaBH<sub>4</sub> or LiAlH<sub>4</sub>
- ignore wrong descriptions for reduction step e.g. hydrolysis or hydration

[11]

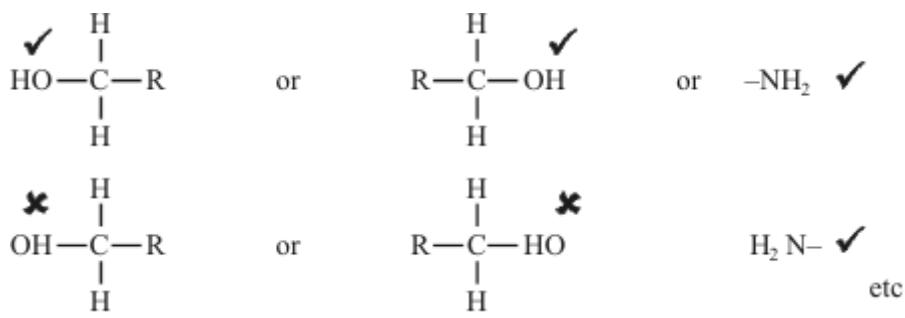
### Organic points

- (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

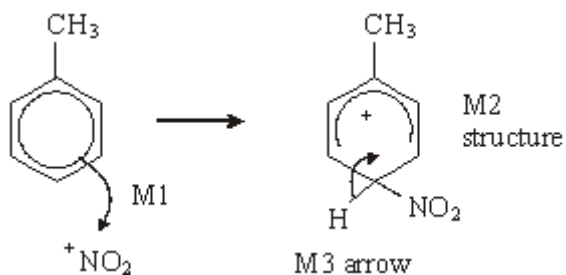
penalise sticks (i.e. ) once per paper



Penalise once per paper

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

- M4.** (a) (i) conc  $\text{HNO}_3$  1
- conc  $\text{H}_2\text{SO}_4$
- 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  $\text{CH}_3$  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 / H<sub>2</sub> not NaBH<sub>4</sub> LiAlH<sub>4</sub>

1

- (c) (i) NH<sub>3</sub>

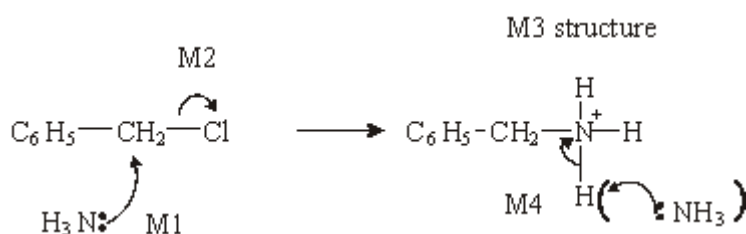
1

Use an excess of ammonia

1

- (ii) nucleophilic substitution

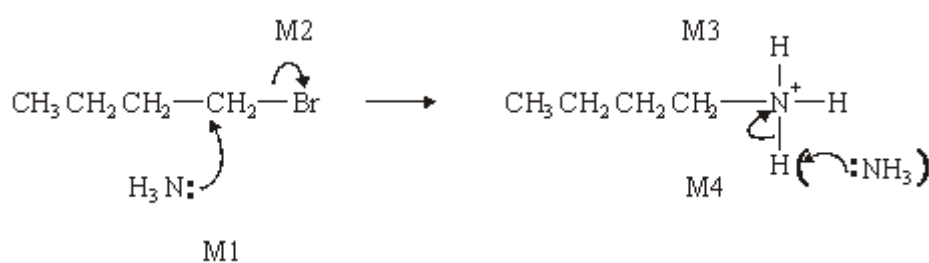
1



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<sup>-</sup> used to remove H<sup>+</sup>)

- 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  $\text{CN}^-$ ) (or  $\text{Br}^-$ )  
(not  $\text{HCN}$ )    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[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]