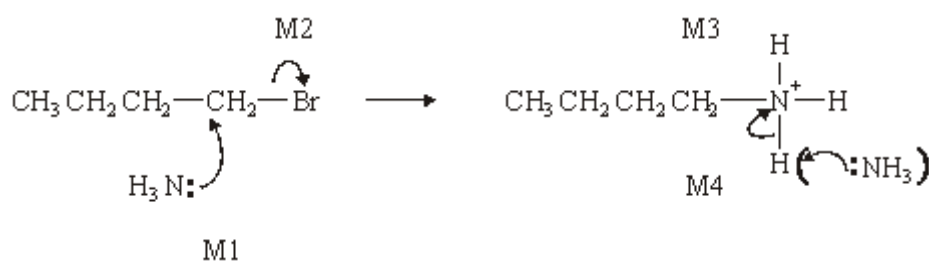


M1. (a) Nucleophilic substitution

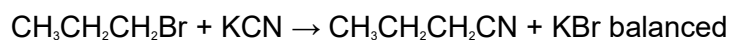


1

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<sup>+</sup>)

4

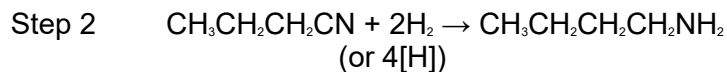
(b) Step 1  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CN}$  1



1

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

1



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]

**M2.** (a) Cyclohexane evolves  $120 \text{ kJ mol}^{-1}$

∴ (expect triene to evolve)  $360 \text{ kJ mol}^{-1}$  **(1)** or  $3 \times 120$

$360 - 208 = 152 \text{ kJ}$  **(1)** NOT 150

*152 can score first 2*

*QoFL: benzene lower in energy / more (stated) stable **(1)***

*Not award if mentions energy required for bond breaking*

*due to delocalisation **(1)** or explained*

4

(b) (i) phenylamine weaker **(1)**

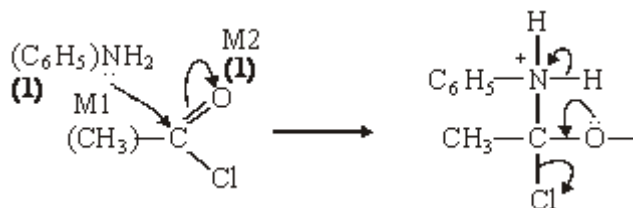
*if wrong no marks*

lone pair on N (less available) **(1)**

delocalised into ring **(1)** or "explained"

3

(ii) addition – elimination **(1)**



*structure **(1)** M3*

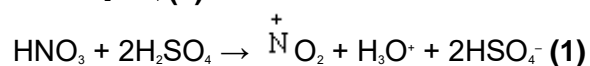
*3 arrows **(1)** M4*

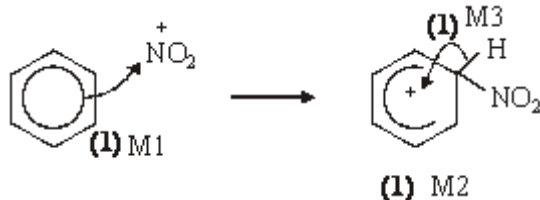
N-phenyl ethanamide **(1)**

6

(iii) conc  $\text{HNO}_3$  **(1)**

conc  $\text{H}_2\text{SO}_4$  **(1)**





6

(iv) peptide / amide (1)

NaOH (aq) (1)

*HCl conc or dil or neither*

*H<sub>2</sub>SO<sub>4</sub> dil NOT conc*

*NOT just H<sub>2</sub>O*

2

### Notes

- (a)
- 360 or  $3 \times 120$  or in words (1);
  - 152 NOT 150 (1); (152 can get first two marks)
  - **Q of L** benzene more stable but not award if  $\Delta H$  values used to say that more energy is required by benzene for hydrogenation compared with the triene or if benzene is only compared with cyclohexene (1);
  - delocalisation or explained (1)

- (b) (ii) or N-phenylacetamide or acetanilide  
 mechanism: if shown as substitution can only gain M1  
 if  $\text{CH}_3\text{CO}^+$  formed can only gain M1  
 lose M4 if  $\text{Cl}^-$  removes  $\text{H}^+$   
 be lenient with structures for M1 and M2 but must be correct for M3  
 $\text{C}=\text{O}$  alone loses M2

- (iii) **No marks for name of mechanism in this part**  
 if conc missing can score one for both acids (or in equation)  
 allow two equations

allow  $\text{HNO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{NO}_2^+ + \text{HSO}_4^- + \text{H}_2\text{O}$

ignore side chain in mechanism even if wrong

arrow for M1 must come from inside hexagon

arrow to  $\text{NO}_2^+$  must go to N but be lenient over position of +

+ must not be too near "tetrahedral" Carbon

horseshoe from carbons 2-6 but don't be too harsh

- (iv) reagent allow NaOH  
 HCl conc or dil or neither  
 H<sub>2</sub>SO<sub>4</sub> dil or neither but not conc  
 not just H<sub>2</sub>O

[21]

**M3.B**

[1]

- M4.** (a) (i) H<sup>+</sup> or proton acceptor **(1)**  
 $\text{CH}_3\text{NH}_2 + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{NH}_3^+ + \text{OH}^-$  **(1)**

- (ii) CH<sub>3</sub>NH<sub>3</sub>Cl or HCl **(1)**  
*Or any ammonium compound or strong acid  
 name or formula*

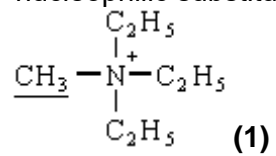
- (iii) extra OH<sup>-</sup> reacts with  $\text{CH}_3\text{NH}_3^+$   
 or reaction / equilibrium moves to left  
 or ratio salt / base remains almost constant **(1)**  
*Any 2*

5

- (b) lone pair (on N accepts H<sup>+</sup>) **(1)**  
 CH<sub>3</sub> increases electron density (on N)  
 donates / pushes electrons  
 has positive inductive effect **(1)**

2

(c) nucleophilic substitution (1)



2

[9]