M1. (a) Cyclohexane evolves 120 kJ mol^{-1}

$\therefore$ (expect triene to evole) 360 kJ mol^{-1} **(1)** or 3 × 120

360 – 208 = 152 kJ **(1)** NOT 150

152 can score first 2

*QofL: benzene lower in energy / <u>more</u> (stated) stable **(1)***
Not award if mentions energy required for bond breaking

*due to <u>delocalisation</u> **(1)** or explained*

4

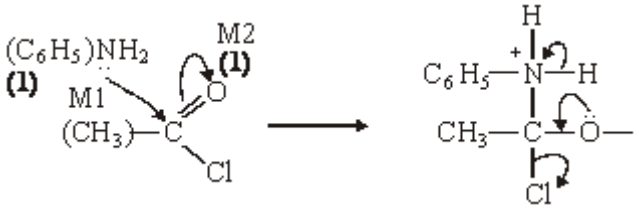
(b) (i) phenylamine weaker **(1)**

if wrong no marks

lone pair on N (less available) **(1)**
delocalised into ring **(1)** or "explained"

3

(ii) addition – elimination **(1)**



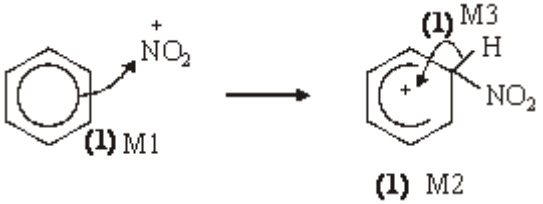
*structure **(1)** M3*
*3 arrows **(1)** M4*

N-phenyl ethanamide **(1)**

6

(iii) conc HNO_3 **(1)**
conc H_2SO_4 **(1)**

$HNO_3 + 2H_2SO_4 \rightarrow {}^{+}NO_2 + H_3O^{+} + 2HSO_4^{-}$ **(1)**



6

(iv) peptide / amide **(1)**

NaOH (aq) **(1)**

HCl conc or dil or neither

H_2SO_4 dil NOT conc

NOT just H_2O

2

Notes

(a)
- 360 or 3 × 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 ΔH 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 CH_3CO+ formed can only gain M1

lose M4 if Cl^- removes H^+

be lenient with structures for M1 and M2 but must be correct for M3

 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 $HNO_3 + H_2SO_4 \rightarrow NO^{2+} + HSO_4^- + H_2O$

ignore side chain in mechanism even if wrong

arrow for M1 must come from niside hexagon

arrow to 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_2SO_4 dil or neither but not conc
not just H_2O

[21]

M2. (a) (i) Moles NaOH = mv/1000 = 1.50 × 72.5/1000 = 0.108 to 0.11 **(1)**
Moles of ethanoic acid at equilibrium = moles sodium hydroxide **(1)**
Moles ester = moles water (=moles acid reacted) **(1)**
= 0.200 – 0.108 = 0.090 to 0.092 **(1)**
Moles ethanol = 0.110 – 0.091 = 0.018 to 0.020 **(1)**
K_c = [Ester] [Water]/[Acid] [Alcohol] **(1)**
Allow if used correctly

= $(0.091)^2/0.109 \times 0.019$ = 3.7 to 4.9 **(1)**
Ignore units
NB Allow the answer 4 one mark as correct knowledge

7

(ii) Similar (types) of bond broken and made **(1)**
Same number of the bonds broken and made **(1)**
any number if equal
NB If a list given then the total number of each type of bond broken and made must be the same

2

(b) (i) (Weak) dipole-dipole attraction between HCl molecules **(1)**
(Strong) **hydrogen bonds** between CH_3COOH molecules **(1)**
NB Ignore van der Waals forces

2

(ii) Ethanoic anhydride is

cheap compared to ethanoyl chloride **(1)**

less corrosive than ethanoyl chloride or HCl evolved **(1)**

reaction less violent or vigorous or exothermic or dangerous or safer to use **(1)**

less vulnerable to hydrolysis **(1)**

reaction more easily controlled **(1)**

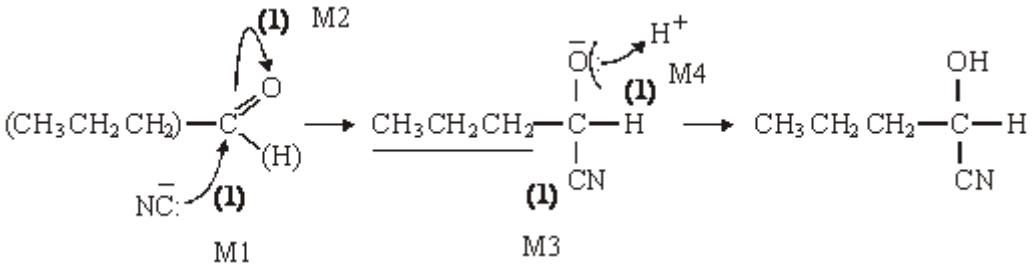
Max 2

[13]

M3.C

[1]

M4.(a) *Mechanism*



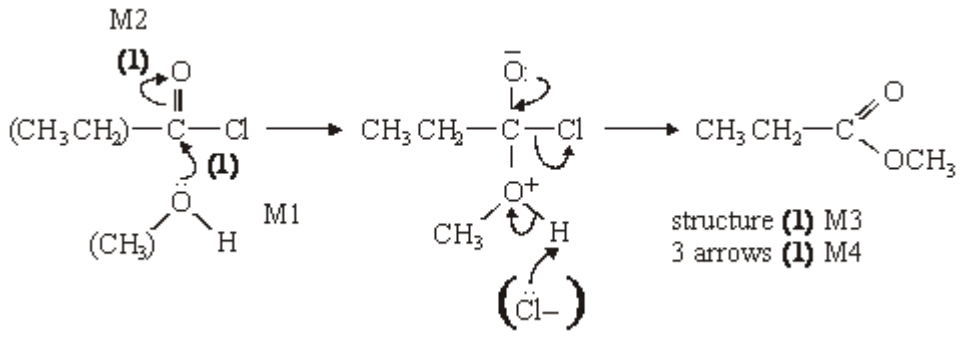
Allow C_3H_7 if structure shown elsewhere
penalise HCN splitting if wrong

Name of product: 2-hydroxypenta(neo)nitrile **(1)**

or 1-cyanobutan-1-ol

5

(b) *Mechanism*

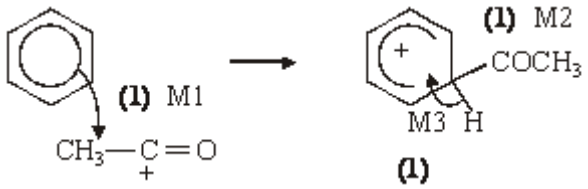


Name of organic product: methylpropanoate **(1)**

5

(c) (i) ([]) CH_3CO (])$^+$ **(1)**

(ii)



4

Notes

(abc) extra curly arrows are penalised

(a) be lenient on position of negative sign on : CN^- but arrow must come from lp

(a)/(b) C=O alone loses M2 but can score M1 for attack on C+, similarly C—Cl

(a) allow 2-hydroxypentanonitrile or 2-hydroxypenta(ne)nitrile ... pentylnitrile

(b) in M4, allow extra: Cl^- attack on H, showing loss of H^+

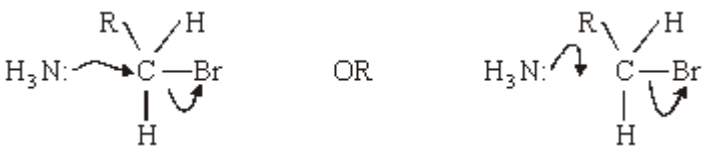
(c) (i) allow formula in an "equation"(balanced or not)
be lenient on the position of the + on the formula

(ii) for M1 the arrow must go to the C or the + on the C
don't be too harsh about the horseshoe, but + must not be close to the saturated C
M3 must be final step not earlier; allow M3 even if structure (M2) is wrong

[14]

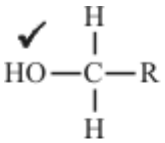
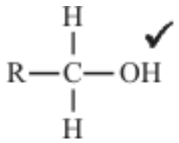
Organic points

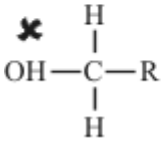
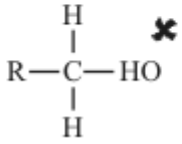
(1) Curly arrows: must show movement of a pair of electrons,
i.e. from bond to atom or from lp to atom / space
e.g.



(2) Structures

penalise sticks (i.e. ) once per paper

 ✓ or  ✓ or $-NH_2$ ✓

 ✗ or  ✗ H_2N- ✓

etc

Penalise once per paper

allow CH_3- or $-CH_3$ or  or CH_3
or H_3C-