M1.C

[1]

M2.B

[1]

M3.A

[1]

M4.D

[1]

M5.B

[1]

M6.D

[1]

M7.B

[1]

M8.A

[1]

M1.(a) (i) 3(-120) − (-208) = -152
OR
3(120) − 208 = 152 (kJ mol^{-1})

Must show working and answer and maths must be correct, but ignore sign

1

(ii) Electrons delocalised OR delocalisation (QOL)
ORallow reference to resonance (QOL)

1

(b) x, y, w

Must be in this order

1

(c) (i) -240 (kJ mol^{-1})

Must have minus sign

1

(ii) between -239 and -121 (kJ mol^{-1})

Must have minus sign

1

(iii) Must specify which diene:

Proximity − for 1,3 C=C bonds are close together

allow converse for 1,4 diene

M1

1

Delocalisation − for 1,3 some delocalisation
OR
some overlap of electrons, π clouds or p orbitals

allow converse for 1,4 diene

M2

1

some extra stability for the 1,3- isomer

M3

1

[8]

M2.(a) Sn / HCl ***OR*** Fe / HCl not conc H_2SO_4 nor any HNO_3

Ignore subsequent use of NaOH

Ignore reference to Sn as a catalyst with the acid

Allow H_2 (Ni / Pt) but penalise wrong metal

But NOT $NaBH_4$ $LiAlH_4$ Na / C_2H_5OH

1

Equation must use molecular formulae

$C_6H_4N_2O_4 + 12\,[H]$

12[H] and $4H_2O$ without correct molecular formula scores 1 out of 2

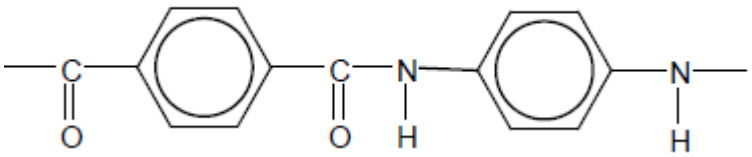
1

$\rightarrow C_6H_8N_2 + 4H_2O$

Allow .... + $6H_2$ if H_2 / Ni used

Allow −CONH− or −COHN− or $-C_6H_4-$

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, $NaBH_4$ etc.

1

CH_2

1

In benzene 120°

1

In cyclohexane 109° 28’ or 109½°

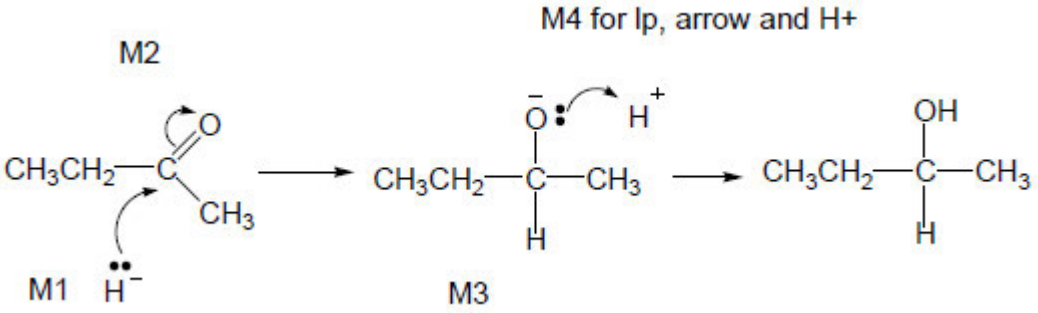
Allow 108° - 110°

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+*
- *+ rather than δ+ on C=O loses M2*
- *M3 is for correct structure including minus sign but lone pair is part of M4*
- *Allow C_2H_5*
- *M1 and M4 include lp and curly arrow*
- *Allow M4 arrow to <u>H</u> in H_2O (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) **M1** Benzene is <u>more stable than cyclohexatriene</u>

more stable than cyclohexatriene must be stated or implied

If benzene more stable than cyclohexene, then penalise M1 but mark on

If benzene less stable: can score M2 only

1

M2 Expected $\Delta H^{\ominus}$ hydrogenation of C_6H_6 is 3(–120)

$= -360$ kJ mol^{-1}

Allow in words e.g. expected $\Delta H^{\ominus}$ hydrog is three times the $\Delta H^{\ominus}$ hydrog of cyclohexene

1

M3 Actual $\Delta H^{\ominus}$ hydrogenation of benzene is

152 kJ mol^{-1} (less exothermic)

or 152 kJ mol^{-1} different from expected

Ignore energy needed

1

M4 Because of delocalisation or electrons spread out or resonance

1

(b) **No mark for name of mechanism**

Conc HNO_3

If either or both conc missing, allow one;

1

Conc H_2SO_4

this one mark can be gained in equation

1

$2\ H_2SO_4 + HNO_3 \rightarrow 2\ HSO_4^- + NO_2^+ + H_3O^+$

OR

$H_2SO_4 + HNO_3 \rightarrow HSO_4^- + NO_2^+ + H_2O$

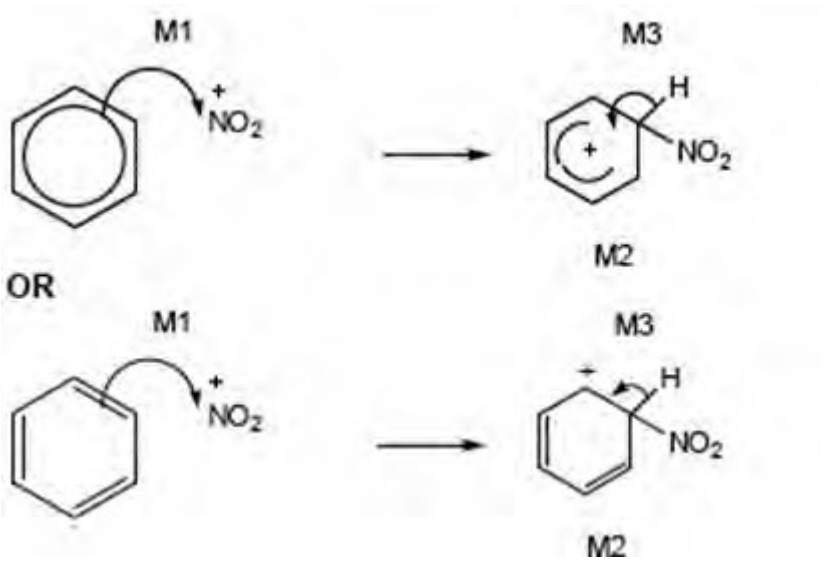
OR via two equations

$H_2SO_4 + HNO_3 \rightarrow HSO_4^- + H_2NO_3^+$

$H_2NO_3+ \rightarrow NO_2^+ + H_2O$

Allow + anywhere on NO_2^+

1



M1 arrow from within hexagon to N or + on N

Allow NO_2^+ in mechanism

horseshoe must not extend beyond C2 to C6 but can be smaller

+ not too close to C1

M3 arrow into hexagon unless Kekule

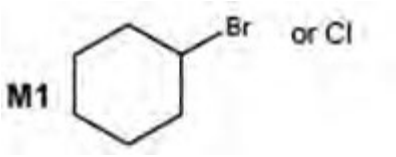
allow M3 arrow independent of M2 structure

ignore base removing H in M3

+ on H in intermediate loses M2 not M3

3

(c) **If intermediate compound V is wrong or not shown, max 4 for 8(c)**



or chlorocyclohexane or bromocyclohexane

1

Reaction 3

M2 HBr

1

M3 Electrophilic addition

Allow M2 and M3 independent of each other

1

Reaction 4

M4 Ammonia if wrong do not gain M5

1

Allow M4 and M6 independent of each other

M5 Excess ammonia or sealed in a tube or under pressure

1

If CE e.g. acid conditions, lose M4 and M5

M6 Nucleophilic substitution

1

(d) Lone or electron <u>pair on N</u>

No marks if reference to ''lone pair on N'' missing

1

Delocalised or spread into ring in U

1

Less available (to accept protons) or less able to donate (to H^+)

1

[19]

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

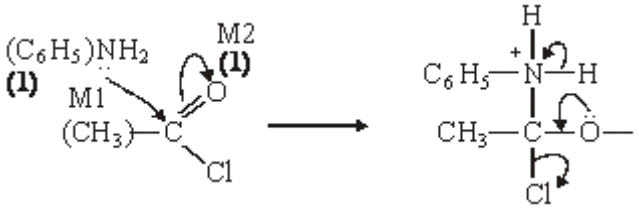
(b) (i) phenylamine weaker **(1)**

if wrong no marks

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

3

(ii) addition – elimination **(1)**



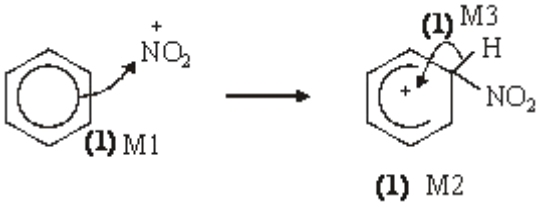
*structure **(1)** M3*
*3 arrows **(1)** M4*

N-phenyl ethanamide **(1)**

6

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

$HNO_3 + 2H_2SO_4 \rightarrow \overset{+}{N}O_2 + H_3O^+ + 2HSO_4^-$ **(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

[1]

M1.(a) Electrophilic substitution

Both words needed

Ignore minor misspellings

1

(b) (i) Sn / HCl

OR H_2 / Ni **OR** H_2 / Pt **OR** Fe / HCl **OR** Zn / HCl **OR** $SnCl_2$ / HCl

Ignore conc or dil with HCl,

Allow (dil) H_2SO_4 but not conc H_2SO_4

Not allow HNO_3 or H^+

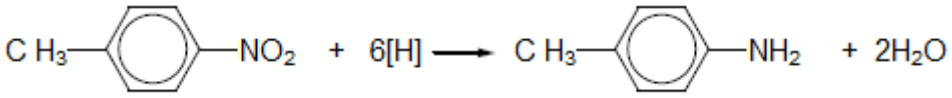
Ignore NaOH after Sn / HCl

Ignore catalyst

1

(ii) $CH_3C_6H_4NO_2 + 6[H] \rightarrow CH_3C_6H_4NH_2 + 2H_2O$

OR



Allow molecular formulae as structures given

$C_7H_7NO_2 + 6[H] \rightarrow C_7H_9N + 2H_2O$

Qu states use [H], so penalised $3H_2$

1

(iii) making dyes

OR making quaternary ammonium salts

OR making (cationic) surfactants

OR making hair conditioner

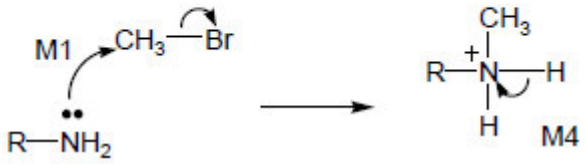
OR making fabric softener

OR making detergents

1

(c)

M2



M3

NO Mark for name of mechanism

Allow SN1

M1 for lone pair on N and arrow to C or mid point of space between N and C

M2 for arrow from bond to Br

M3 for structure of protonated secondary amine

M4 for arrow from bond to N or + on N

For M4: ignore RNH_2 or NH_3 removing H^+ but penalise Br^-

4

(d) <u>lone or electron pair on N</u>

If no mention of lone pair CE = 0

If lone pair mentioned but not on N then lose M1 and mark on

M1

1

in **J** spread / delocalised into ring (or not delocalised in K)

Ignore negative inductive effect of benzene

*Allow interacts with **Π** cloud for M2*

M2

1

less available (for protonation or donation in **J**)

M3

OR

in **K** there is a positive inductive effect / electron releasing)

M2

more available (for protonation or donation in **K**)

M3

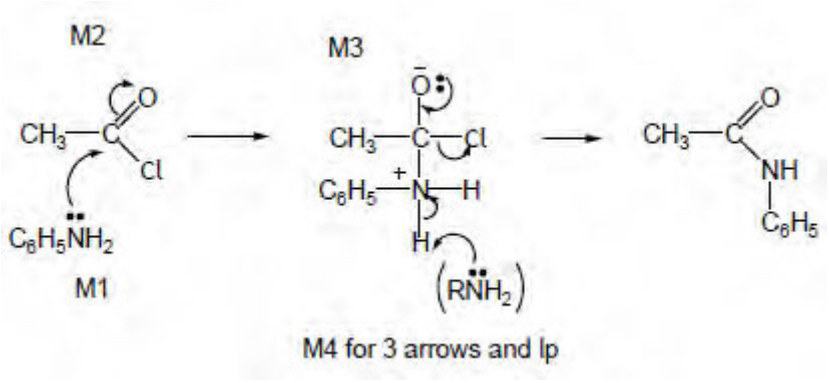
1

[11]

M2.(a) (nucleophilic) addition-elimination

Not electrophilic addition-elimination

1



Allow C_6H_5 or benzene ring

Allow attack by :$NH_2C_6H_5$

M2 not allowed independent of M1, but allow M1 for correct attack on C+

M3 for correct structure <u>with charges</u> but lone pair on O is part of M4

M4 (for three arrows and lone pair) can be shown in more than one structure

4

(b) **The minimum quantity of hot water was used:**

To ensure the hot solution would be saturated / crystals would form on cooling

1

The flask was left to cool before crystals were filtered off:

Yield lower if warm / solubility higher if warm

1

The crystals were compressed in the funnel:

Air passes through the sample not just round it

Allow better drying but not water squeezed out

1

A little cold water was poured through the crystals:

To wash away soluble impurities

1

(c) Water

Do not allow unreacted reagents

1

Press the sample of crystals between filter papers

Allow give the sample time to dry in air

1

(d) M_r product = 135.0

1

Expected mass = $5.05 \times \frac{135.0}{93.0} = 7.33$ g

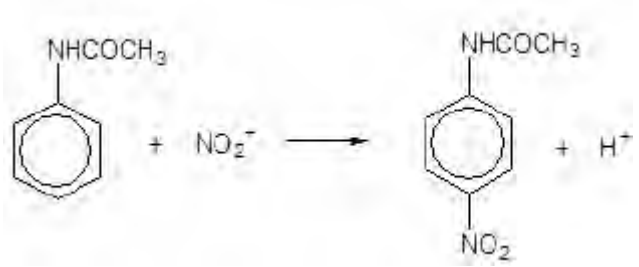
1

Percentage yield = $\frac{4.82}{7.33} \times 100 = 65.75 = 65.8(\%)$

Answer must be given to this precision

1

(e)



OR

$C_6H_5NHCOCH_3 + NO_2^+ \rightarrow C_6H_4(NHCOCH_3)NO_2 + H^+$

1

(f) Electrophilic substitution

1

(g) Hydrolysis

1

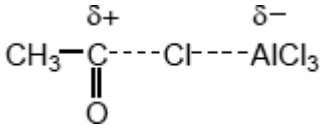
(h) Sn / HCl

Ignore acid concentration; allow Fe / HCl

1

[18]

M3.(a) $CH_3COCl + AlCl_3 \longrightarrow CH_3CO^+ + AlCl_4^-$



Allow RHS as

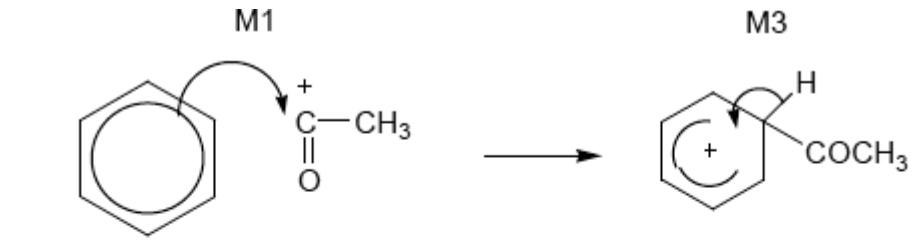
Allow + on C or O in equation but + must be on C in mechanism below

Ignore curly arrows in equation even if wrong.

1

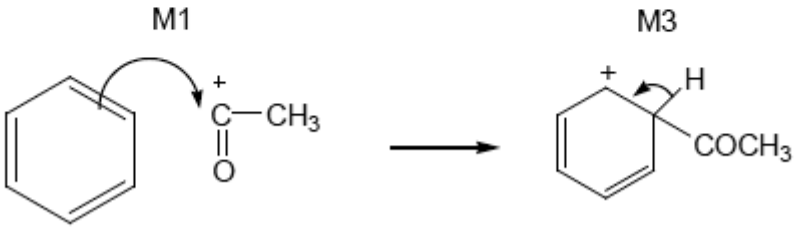
$AlCl_4^- + H^+ \longrightarrow AlCl_3 + HCl$

1



M2

OR



M2

- *M1 arrow from within hexagon to C or to + on C*
- *+ must be on C of RCO in mechanism*
- *+ in intermediate not too close to C1*
- *gap in horseshoe must be centred approximately around C1*
- *M3 arrow into hexagon unless Kekule*
- *allow M3 arrow independent of M2 structure*
- *ignore base removing H for M3*
- ***NO** mark for name of mechanism*

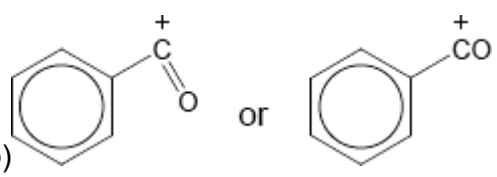
3

Phenylethanone ignore 1 in name, penalise other numbers

Note: this is the sixth marking point in (a)

1

(b)



+ must be on C

But allow $[C_6H_5CO]^+$

1

(c) M1 about electrons

methyl group has (positive) inductive effect OR increases electron density on benzene ring OR pushes electrons OR is electron releasing

Ignore reference to delocalisation

1

M2 about attraction

electrophile attracted more

or benzene ring better nucleophile

Allow intermediate ion stabilised

M2 only awarded after correct or close M1

1

[9]

M4.(a) Hydrogen <u>bond</u>(ing)

Allow H bonding.

Penalise mention of any other type of bond.

1

(b) (i) Ammonia is a nucleophile

Allow ammonia has a lone pair.

1

Benzene repels nucleophiles

Allow (benzene) attracts / reacts with electrophiles.

***OR** benzene repels electron rich species or lone pairs.*

***OR** C–Cl bond is short / strong / weakly polar.*

1

(ii) H_2 / Ni **OR** H_2 / Pt **OR** Sn / HCl **OR** Fe / HCl

Ignore dil / conc of HCl.

Ignore the term 'catalyst'.

Allow H_2SO_4 with Sn and Fe but not conc.

Ignore NaOH following correct answer.

Not $NaBH_4$ nor $LiAlH_4$.

1

(iii) <u>conc HNO_3</u>

<u>conc H_2SO_4</u>

1

If either or both conc missed can score 1 for both acids.

1

$HNO_3 + 2H_2SO_4 \longrightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$

OR using two equations

$HNO_3 + H_2SO_4 \longrightarrow H_2NO_3^+ + HSO_4^-$

$H_2NO_3^+ \longrightarrow H_2O + NO_2^+$

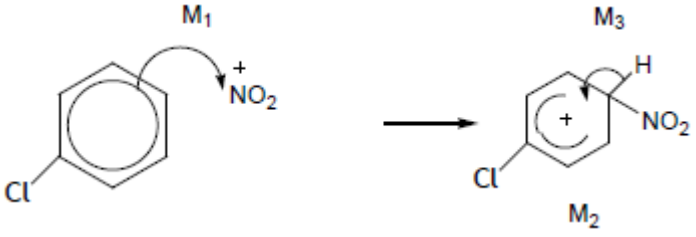
Allow 1:1 equation.

$HNO_3 + H_2SO_4 \longrightarrow NO_2^+ + H_2O + HSO_4^-$.

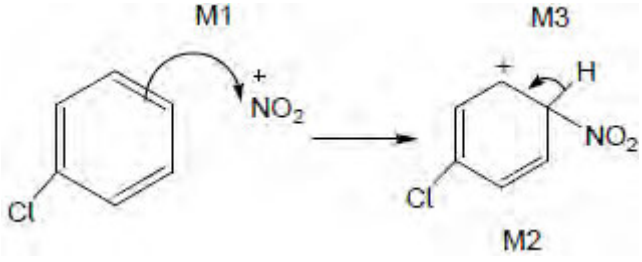
1

(iv) <u>Electrophilic substitution</u>

1



OR

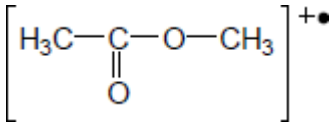


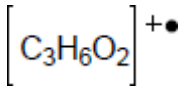
- *Ignore position or absence of Cl in M1 but must be in correct position for M2.*
- *M1 arrow from within hexagon to N or <u>+ on N</u>.*
- *Allow NO_2^+ in mechanism.*
- *Bond to NO_2 must be to N for structure mark M2.*
- *Gap in horseshoe must be centered around correct carbon (C1).*
- *+ in intermediate not too close to C1 (allow on or "below" a line from C2 to C6).*
- *M3 arrow into hexagon unless Kekule.*

- *Allow M3 arrow independent of M2 structure.*
- *Ignore base removing H in M3.*
- *+ on H in intermediate loses M2 not M3.*

3

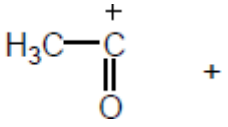
[11]

M5.(a) 

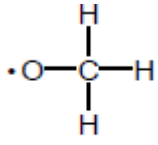
OR 

NOT penalise missing brackets.
If wrong ester, no further mark.

1

→ 

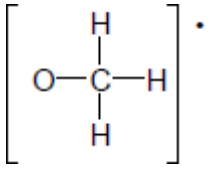
Must be displayed formula



(1)

Radical dot must be on O
Ignore lone pair(s) on O in addition to single electron

Allow radical with brackets as



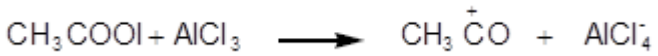
Ignore errors in acylium ion.

1

(b) (i) $AlCl_3$ or $FeCl_3$

If wrong no further marks.

1



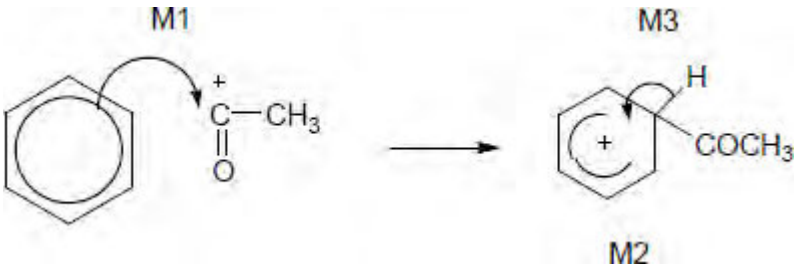
Correct equation scores 2 - contrast with (b)(iii)
Allow + on C or O in equation.

1

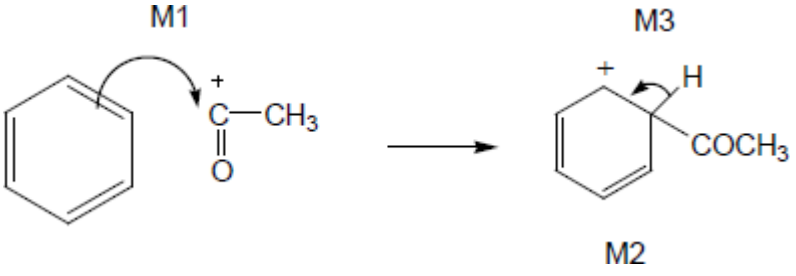
(ii) Electrophilic substitution

Ignore Friedel crafts.

1



OR

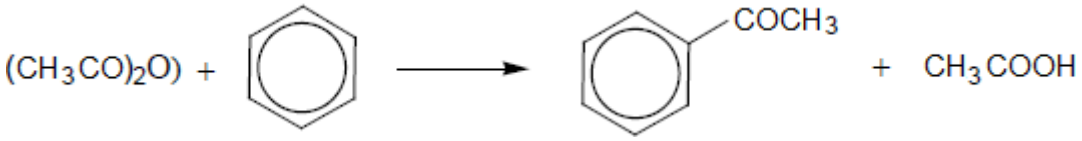


- *+ must be on C of RCO here*
- *M1 arrow from within hexagon to C or to + on C*
- *Gap in horseshoe must approximately be centred around C1 and not extend towards C1 beyond C2 and C6*
- *+ not too close to C1*
- *M3 arrow into hexagon unless Kekule*
- *allow M3 arrow independent of M2 structure, i.e. + on H in intermediate loses M2 not M3*
- *ignore base removing H for M3*

3

(iii) $(CH_3CO)_2O + C_6H_6 \longrightarrow C_6H_5COCH_3 + CH_3COOH$

OR



Correct equation scores 1 – contrast with (b)(i)

Not allow molecular formula for ethanoic anhydride or ethanoic acid.

1

[9]

M1.(a) (i) Conc HNO_3

If either or both conc missing, allow one;

1

Conc H_2SO_4

this one mark can be gained in equation`

1

$2\ H_2SO_4 + HNO_3 \longrightarrow 2\ HSO_4^- + NO_2^+ + H_3O^+$

1

OR $H_2SO_4 + HNO_3 \longrightarrow HSO_4^- + NO_2^+ + H_2O$

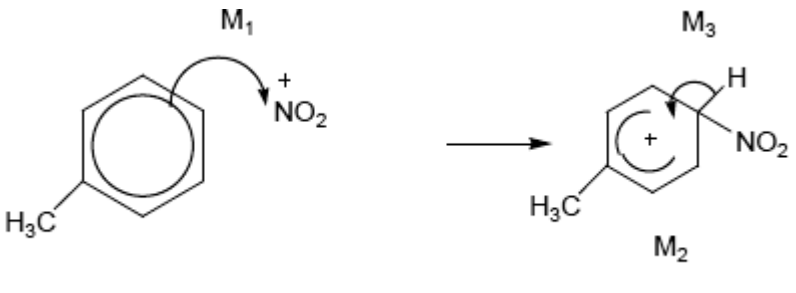
Allow + anywhere on NO_2^+

OR via two equations

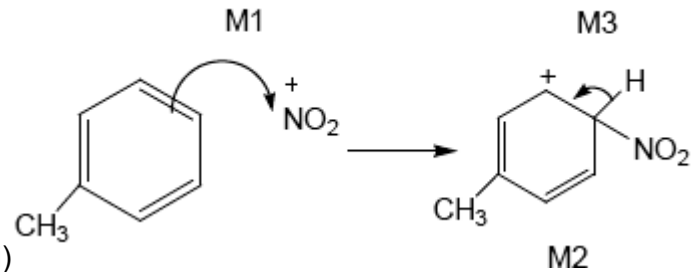
$H_2SO_4 + HNO_3 \longrightarrow HSO_4^- + H_2NO_3^+$

$H_2NO_3^+ \longrightarrow NO_2^+ + H_2O$

(ii)



OR



- *ignore position or absence of methyl group in M1 but must be in correct position for M2*
- *M1 arrow from within hexagon to N or <u>+ on N</u>*
- *Allow NO_2^+ in mechanism*
- *Bond to NO_2 must be to N*

- *horseshoe must not extend beyond C2 to C6 but can be smaller*
- *+ not too close to C1*
- *M3 arrow into hexagon unless Kekule*
- *allow M3 arrow independent of M2 structure*
- *ignore base removing H in M3*
- *+ on H in intermediate loses M2 not M3*

3

(b) 5

1

(c) 2

1

(d) $2C_7H_5N_3O_6 \longrightarrow 5H_2O + 3N_2 + 7C + 7CO$

Or halved

1

[9]

M2. (a) **M1** Benzene is <u>more stable than cyclohexatriene</u>

more stable than cyclohexatriene must be stated or implied

If benzene more stable than cyclohexene, then penalise M1 but mark on

If benzene less stable: can score M2 only

1

M2 Expected $\Delta H^{\ominus}$ hydrogenation of C_6H_6 is 3(–120)

$= -360$ kJ mol^{-1}

Allow in words e.g. expected $\Delta H^{\ominus}$ hydrog is three times the $\Delta H^{\ominus}$ hydrog of cyclohexene

1

M3 Actual $\Delta H^{\ominus}$ hydrogenation of benzene is

152 kJ mol^{-1} (less exothermic)

or 152 kJ mol^{-1} different from expected

Ignore energy needed

1

M4 Because of delocalisation or electrons spread out or resonance

1

(b) **No mark for name of mechanism**

Conc HNO_3

If either or both conc missing, allow one;

1

Conc H_2SO_4

this one mark can be gained in equation

1

$2\ H_2SO_4 + HNO_3 \rightarrow 2\ HSO_4^- + NO_2^+ + H_3O^+$

OR

$H_2SO_4 + HNO_3 \rightarrow HSO_4^- + NO_2^+ + H_2O$

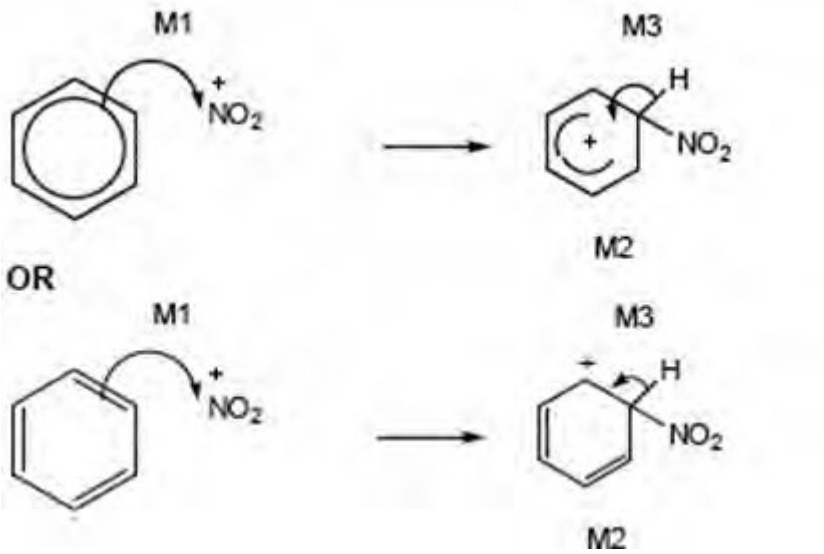
OR via two equations

$H_2SO_4 + HNO_3 \rightarrow HSO_4^- + H_2NO_3^+$

$H_2NO_3+ \rightarrow NO_2^+ + H_2O$

Allow + anywhere on NO_2^+

1



M1 arrow from within hexagon to N or + on N

Allow NO_2^+ in mechanism

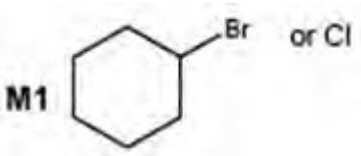
horseshoe must not extend beyond C2 to C6 but can be

smaller
+ not too close to C1
M3 arrow into hexagon unless Kekule
allow M3 arrow independent of M2 structure
ignore base removing H in M3
+ on H in intermediate loses M2 not M3

3

(c) **If intermediate compound V is wrong or not shown, max 4 for 8(c)**

M1



or chlorocyclohexane or bromocyclohexane

1

Reaction 3

M2 HBr

1

M3 Electrophilic addition

Allow M2 and M3 independent of each other

1

Reaction 4

M4 Ammonia if wrong do not gain M5

1

Allow M4 and M6 independent of each other

M5 Excess ammonia or sealed in a tube or under pressure

1

If CE e.g. acid conditions, lose M4 and M5

M6 Nucleophilic substitution

1

(d) Lone or electron pair on N

No marks if reference to ''lone pair on N'' missing

1

Delocalised or spread into ring in U

1

Less available (to accept protons) or less able to donate (to H^+)

1

[19]

M3. C

[1]

M4. (a) CH_3CH_2COCl OR CH_3CH_2CClO OR propanoyl chloride
OR $(CH_3CH_2CO)_2O$ OR propanoic anhydride
penalize contradiction in formula and name e.g. propyl chloride
could score in equation

1

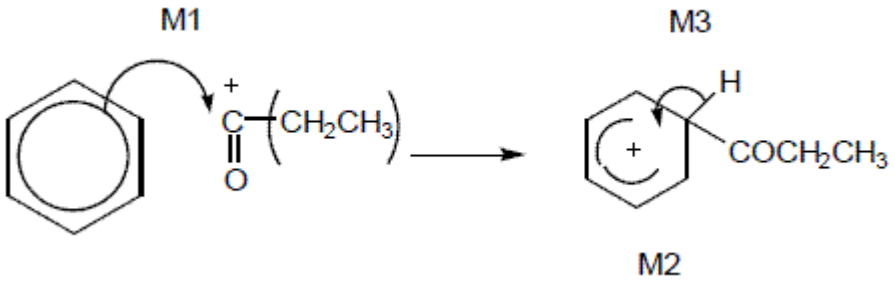
$AlCl_3$ or $FeCl_3$ or names
could score in equation

1

$CH_3CH_2COCl + AlCl_3 \rightarrow CH_3CH_2CO^+ + AlCl_4^-$
Allow RCOCl in equation but penalise above
allow + on C or O in equation

1

(b)



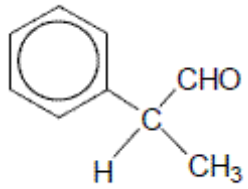
M1 arrow from circle or within it to C or to + on C
Horseshoe must not extend beyond C2 to C6 but can be smaller + not too close to C1
M3 arrow into hexagon unless Kekule
allow M3 arrow independent of M2 structure

Ignore base removing H in M3

3

(c) Tollens or ammoniacal silver nitrate

1



penalise wrong formula

1

[8]

M5. (a) (i) $C_6H_6 + CH_3CH_2COCl \rightarrow C_6H_5COCH_2CH_3 + HCl$

OR

$C_6H_6 + CH_3CH_2CO^+ \rightarrow C_6H_5COCH_2CH_3 + H^+$

allow C_2H_5
penalise C_6H_5–CH_3CH_2CO
allow + on C or O in equation

1

Phenylpropanone

OR ethylphenylketone **OR** phenylethylketone

Ignore 1 in formula, but penalise other numbers

1

$AlCl_3$

can score in equation

1

$CH_3CH_2COCl + AlCl_3 \rightarrow CH_3CH_2CO^+ + AlCl_4^-$

allow C_2H_5
allow + on C or O in equation

1

$AlCl_4^- + H^+ \rightarrow AlCl_3 + HCl$

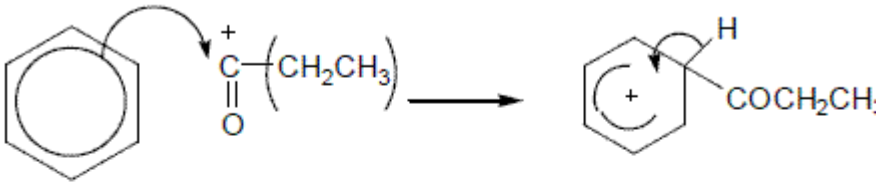
1

(ii) electrophilic substitution

can allow in (a)(i) if no contradiction

1

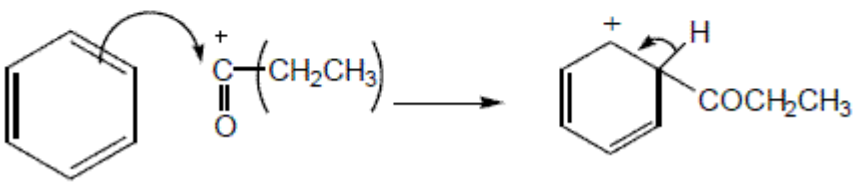
M1 M3



M2
for structure

OR

M1 M3



M2

M1 arrow from circle or within it to C or to + on C
horseshoe must not extend beyond C2 to C6 but can be smaller
+ not too close to C1
M2 penalise C_6H_5–CH_3CH_2CO (even if already penalized in (a)(i))
M3 arrow into hexagon unless Kekule
allow M3 arrow independent of M2 structure
ignore base removing H in M3

3

(b) (i) $CH_3CH_2\underline{CHO} + HCN \rightarrow CH_3CH_2CH(OH)CN$ **OR** $C_2H_5CH(OH)CN$

aldehyde must be –CHO brackets optional

1

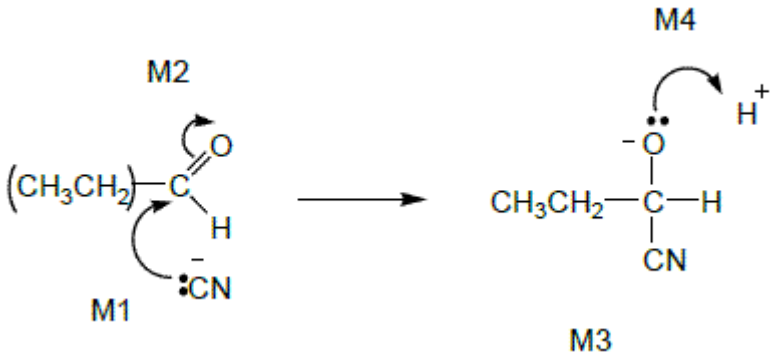
2-hydroxybutanenitrile **OR** 2-hydroxybutan<u>o</u>nitrile

no others

1

(ii) nucleophilic addition

1



M1 includes lp and arrow to Carbonyl C and minus charge (on either C or N)
Not allow M2 before M1, but allow M1 to C^+ after non-scoring carbonyl arrow
Ignore δ+, δ– on carbonyl group, but if wrong way round or full + charge on C lose M2
M3 for correct structure including minus sign. Allow C_2H_5
M4 for lp and curly arrow to H^+

4

(iii) (propanone) slower ***OR*** <u>propanal</u> faster

1

inductive effects of alkyl groups
OR
C of C=O less δ+ in propanone
OR
alkyl groups in ketone hinder attack
OR
easier to attack at end of chain

if wrong, no further marks

1

[18]

M1.

Mark Range	The marking scheme for this part of the question includes an overall assessment for the Quality of Written Communication (QWC). There are no discrete marks for the assessment of QWC but the candidates' QWC in this answer will be one of the criteria used to assign a level and award the marks for this part of the question **Descriptor** an answer will be expected to meet most of the criteria in the level descriptor
4-5	– claims supported by an appropriate range of evidence – good use of information or ideas about chemistry, going beyond those given in the question – argument well structured with minimal repetition or irrelevant points – accurate and clear expression of ideas with only minor errors of grammar, punctuation and spelling
2-3	– claims partially supported by evidence – good use of information or ideas about chemistry given in the question but limited beyond this – the argument shows some attempt at structure – the ideas are expressed with reasonable clarity but with a few errors of grammar, punctuation and spelling
0-1	– valid points but not clearly linked to an argument structure – limited use of information or ideas about chemistry – unstructured – errors in spelling, punctuation and grammar or lack of fluency

(a) (i) M_r of $C_6H_5NH_2$ = 93 M_r of CH_3COCl = 78.5
total M_r of reagents = 264.5

1

$$\% \text{ atom economy} = \frac{M_r \text{ of wanted product}}{\text{total } M_r \text{ of all reagents}} \times 100 \text{ QWC}$$

1

$$= \frac{135}{264.5} \times 100 = 51.0\ \%$$

1

(ii) expected yield = $\frac{10}{93} \times 0.5 \times 135 = 7.26$ kg

1

$$\%\ \text{yield} = \frac{5.38}{7.26} \times 100 = 74.1\ \%$$

1

(iii) Although yield appears satisfactory (74%) % atom economy is only 51% QWC

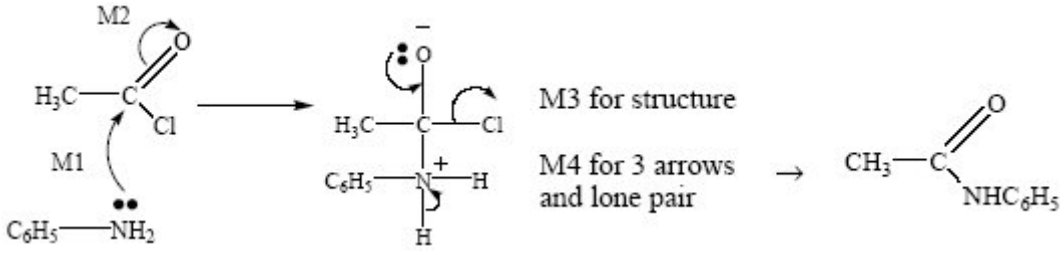
1

nearly half of the material produced is waste and must be disposed of QWC

1

(b) (nucleophilic) addition-elimination

1

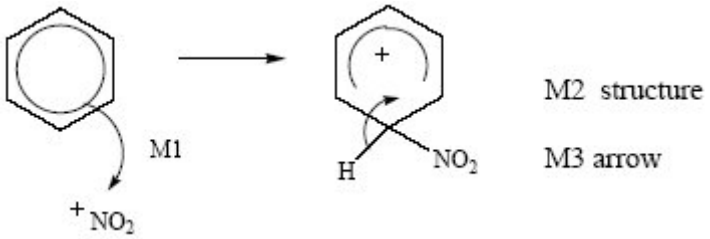


QWC (2)

4

(c) $HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$

1



3

[16]

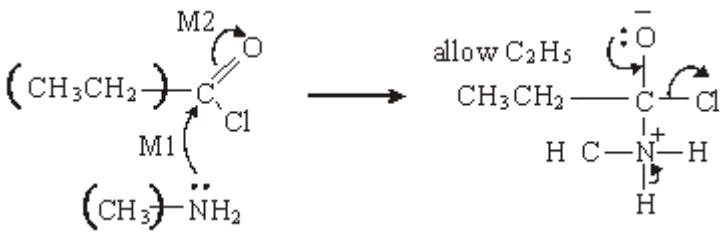
M2.D

[1]

M3.B

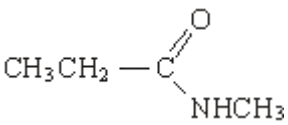
[1]

M4. (a) (nucleophilic) addition-elimination;



(M3 for structure)
(M4 for 3 arrows and lone pair)
(M2 not allowed independent of M1, but allow M1 for correct attack
on C+ if M2 show as independent first.)
(+on C of C=O loses M2 but ignore δ+ if correct)
(Cl$^-$ removing Ft loses M4)

1



(If MS lost above for wrong C chain, do not penalise same error again here)

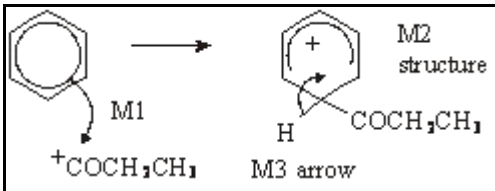
5

(b) $CH_3CH_2COCl + AlCl_3 \rightarrow [CH_3CH_2CO]^+ + AlCl_4^-$;

(penalise wrong alkyl group once at first error)
(position of + on electrophile can be on O or C or outside [ ])
(penalise wrong curly arrow in the equation or lone pair on

$AlCl_3$)

1

 *(M1 arrow from within hexagon to C or to + on C)* *(don't penalise position of + on C of RCO+)*	*(horseshoe must not extend beyond C2 to C6 but can be smaller)* *(+ not too close to C1)* *(penalise M2 if CH_3 chain wrong again but allow M1 and M3)* *(M3 arrow into hexagon unless Kekule)* *(allow M3 arrow independent of M2 structure)*

3

$AlCl_4^- + H^+ \rightarrow AlCl_3 + HCl$;

(or can be gained in mechanism);

1

(c) M1 $CH_3CH_2COCl + H_2O \rightarrow CH_3CH_2COOH + HCl$ 1
(penalise wrong alkyl group once at first error)

1

M2 M_r of CH_3CH_2COCl = 92.5 1
(if Mr wrong, penalise M2 only)

1

M3 moles of CH_3CH_2COCl = 1.48/92.5 = 0.016 1

1

M4 moles NaOH = 2 × 0.016 = 0.032 1
(allow for × 2 conseq to wrong no of moles)

1

M5 volume of NaOH = 0.032/0.42 = 0.0762 dm^3 or 76.2 cm^3 1
(with correct units)
(if ×2 missed in M4 lose M5 also)

1

[16]

M5. (a) $CH_3COCl + AlCl_3 \rightarrow CH_3\overset{+}{C}O + AlCl_4^-$

(1) equation (1)

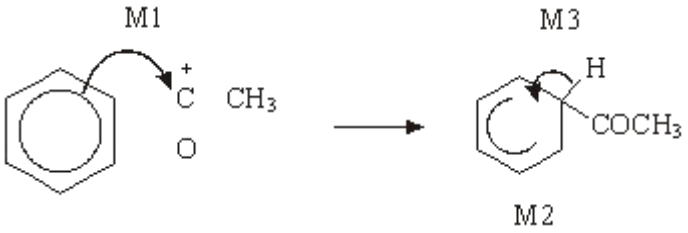
2

penalise wrong alkyl group once at first error
position of + on electrophile can be on O or C or outside [ ]
penalise wrong curly arrow in the equation or lone pair on $AlCl_3$ else ignore

Electrophilic substitution

NOT F/C acylation

1



horseshoe must not extend beyond C2 to C6 but can be smaller

+ not too close to C1

M3 arrow into hexagon unless Kekule

allow M3 arrow independent of M2 structure

M1 arrow from within hexagon to C or to + on C

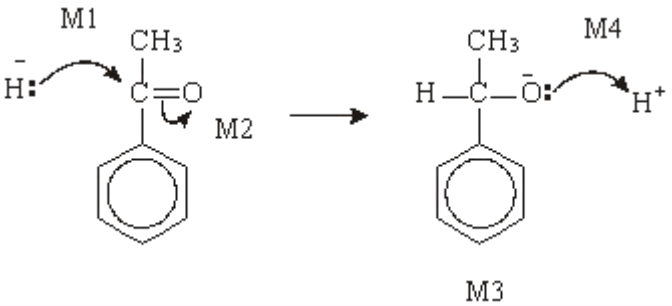
+ must be on C of $\overset{+}{R}CO$

3

(b) Nucleophilic addition

NOT reduction

1



M2 not allowed independent, but can allow M1 for attack of

H^- on C+ formed

4

1–phenylethan(–1–)ol or (1–hydroxyethyl)benzene

1

(c) dehydration or elimination

1

(conc) H_2SO_4 or (conc) H_3PO_4

allow dilute and Al_2O_3

Do not allow iron oxides

1

[14]