**1.** (a) (i) $C_6H_6 + HNO_3 \rightarrow C_6H_5NO_2 + H_2O$ **(1)** 1

(ii) (concentrated) sulphuric acid **(1)** 1

(accept $H_2SO_4$ but give 0 marks for dilute / (aq))

(iii) $NO_2^+$ **(1)** 1

(b) (i) $Cl_2 \rightarrow 2Cl\bullet$ / ½ $Cl_2 \rightarrow Cl\bullet$ **(1)** 1

(ii) $Cl\bullet + C_6H_5CH_3 \rightarrow C_6H_5CH_2\bullet + HCl$ **(1)**

$C_6H_5CH_2\bullet + Cl_2 \rightarrow Cl\bullet + C_6H_5CH_2Cl$ **(1)** 2

(iii) $C_6H_5CHCl_2$ / $C_6H_5CCl_3$ / $C_6H_5\ CHCHC_6\ H_5$ /
other correct possible answer **(1)** 1

(c) (i) $^-CN$ adding to ethanal correctly showing curly arrow **and** curly arrow from double bond in C = O

$CH_3CH(CN) - O^-$

$H^+$ adding to above ion to form product – ignore curly arrows **(1)** 3

(ii) reaction 1 is nucleophilic **(1)**

reaction 2 is electrophilic **(1)** 2

**or** accurate idea of why nucleophile / electrophile attacks aldehyde / alkene including polarity

(d) (i) to satisfy market demand for smaller / unsaturated molecules / alkenes **(1)**

1

(ii) eg $C_{14}H_{30} \rightarrow C_2H_4 + C_{12}H_{26}$ **(1)** 1

(iii) oxide(s) of S and their effect eg acid rain

not just pollutant or toxic **(1)** 1

**[15]**

**2.** (a) Step 1:

*Type of reaction* nitration <u>or</u> electrophilic substitution **(1)**

*Reagent(s)* $CHNO_3 + CH_2SO_4$ **(1)**

Step 3:

*Type of reaction* reduction <u>or</u> amination <u>or</u> hydrogenation **(1)**

*Reagent(s)* HCl/Fe <u>or</u> Sn <u>or</u> Zn <u>or</u> $SnCl_2$ $H_2$/Ni <u>or</u> Cu <u>or</u> Pt <u>or</u> Pd **(1)** 4

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

**[6]**

**3.** (a) *Reagents* $AlCl_3$ **(1)**

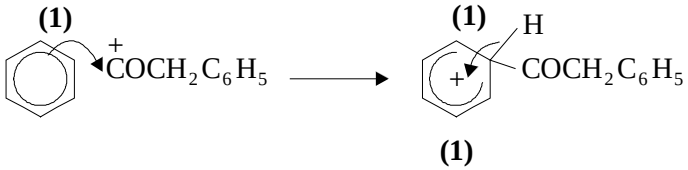
$C_6H_5CH_2COCl$ <u>or</u> $(C_6H_5CH_2CO)_2O$ **(1)**

*Equation for formation of reactive intermediate*

$C_6H_5CH_2COCl + AlCl_3 \rightarrow C_6H_5CH_2CO^+$ **(1)** $AlCl_4^-$ **(1)**

*Name of mechanism* electrophilic substitution **(1)**

*Mechanism*

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(b) *Type of reaction* reduction <u>or</u> hydrogenation **(1)**

*Reagent(s)* $NaBH_4$ <u>or</u> $LiAlH_4$ $H_2$/Ni <u>or</u> Pt <u>or</u> Pd **(1)**
<u>or</u> Na/EtOH

2

(c) *Reagents* $H_2SO_4$ <u>or</u> $H_3PO_4$ <u>or</u> $Al_2O_3$ **(1)**

*Name of mechanism* elimination **(1)**

2

(d) optical

1

(e) *Type of isomerism* geometrical <u>or</u> cis-trans **(1)**

*Explanation* restricted rotation <u>or</u>
double bond rigid **(1)**

2

**[15]**

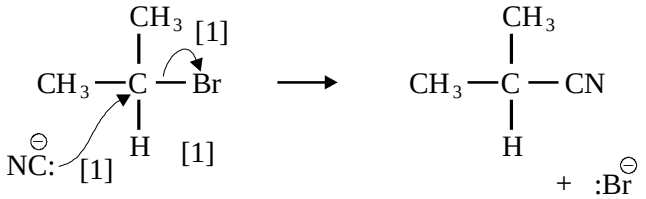
**4.** (a) (i) 2–methylpropanenitrile **(1)**

(ii) Reagent KCN **(1)**

Conditions alcoholic/aq **(1)**

(iii) *Name of mechanism* nucleophilic substitution **(1)**

*Mechanism*




7

(b) *Reagents* conc $HNO_3$ **(1)** conc $H_2SO_4$ **(1)**

*Name of mechanism* electrophilic substitution **(1)**

*Equation* $C_6H_6 + HNO_3 \rightarrow C_6H_5NO_2 + H_2O$

or $C_6H_6 + NO_2^+ \rightarrow C_6H_5NO_2 + H^+$ **(1)**

4

(c) electron deficient C or ä + C in $C_3H_7Br$ **(1)**

attracts/attacked by nucleophiles **(1)**

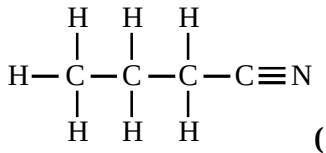
electron rich/delocalized electrons in $C_6H_6$ **(1)**

repels/not attacked by nucleophiles **(1)** max 3

**[14]**

**5.** (a) (i) nucleophilic addition **(1)** 1

(ii) 2-hydroxybutanenitrile condone missing hyphen **(1)**



**(1)** 2

(b) (i) $CH_3CH_2CH_2Br + KCN \rightarrow CH_3CH_2CH_2CN + KBr$ **(1)** 1

allow $C_3H_7Br$ allow $C_4H_7N$

(ii) nucleophilic substitution / SN2 **(1)** 1

(c) $CN^-$ **or** $NC^-$ **(1)**

lone pair of electrons on C atom **(1)** 2

(d) chloromethane or $CH_3Cl$ (or Br or I) **(1)**

$AlCl_3$ / $FeCl_3$ / $AlBr_3$ (as reagent or condition) **(1)**

anhydrous (ignore reference to temperature) **(1)**

electrophilic substitution **(1)** 4

**[11]**

**6.** (a) $CH_3CH_2CH = CH_2 + AlCl_3 + HCl \rightarrow CH_3CH_2\overset{+}{C}HCH_3$ **(1)**

$+ AlCl_4^-$ **(1)** 2

(b) electrophilic substitution **(1)** 1

(c) alternative $CH_3CH_2CH_2CH_2^+$ <u>or</u> primary **(1)**
less stable <u>or</u> 1 v 2 inductive effects **(1)**
than $CH_3CH_2\overset{+}{C}HCH_3$ <u>or</u> secondary **(1)** 3

(d) protonation gives $CH_3CH_2\overset{+}{C}HCH_3$ only **(1)**
<u>or</u> but–2–ene symmetrical 1

(e) $CH_3CH_2\underset{\displaystyle Cl}{\underset{|}{C}}HCH_3$ **(1)**

or Br 1

**[8]**

**7.** (a) (i) $CH_3COCl$ <u>or</u> $(CH_3CO)_2O$ **(1)**

$AlCl_3$ **(1)**

(ii) reduction <u>or</u> hydrogenation **(1)**

(iii) $NaBH_4$ <u>or</u> $LiAlH_4$ <u>or</u> $Na/C_2H_5OH$ <u>or</u> $H_2/Ni$ **(1)**
(<u>or</u> $H_2/Ni$)

(iv) elimination <u>or</u> dehydration **(1)**

$H_2SO_4$ or $H_3PO_4$ <u>or</u> hot $Al_2O_3$ **(1)**

6

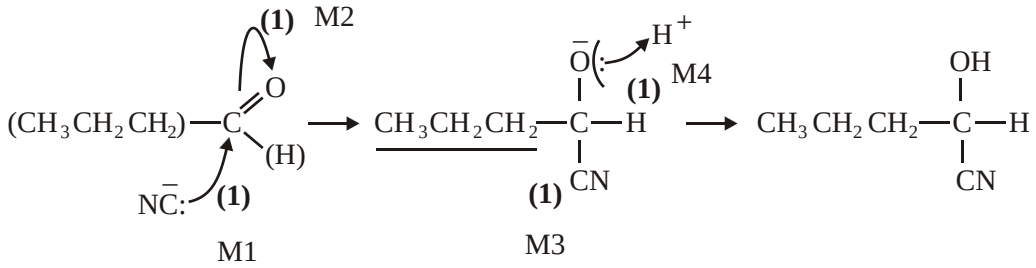
(b) (i) poly(phenylethene) <u>or</u> polystyrene **(1)**

(ii) $CH_3CH_2^+$ <u>or</u> $C_2H_5^+$ **(1)**
$CH_2 = CH_2 + HCl + AlCl_3 \rightarrow CH_3CH_2^+AlCl_4^-$ **(1)**

(iii) elimination <u>or</u> dehydrogenation **(1)** 4

**[10]**

**8.** (a) *Mechanism*

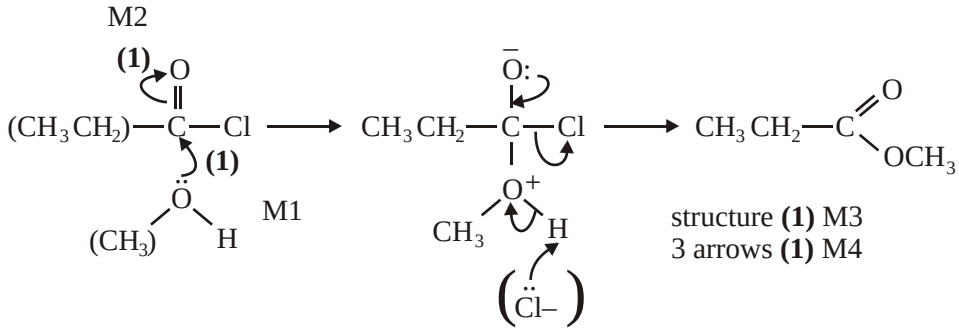



*Allow $C_3H_7$ if structure shown elsewhere*

*penalise HCN splitting if wrong*

*Name of* product: 2-hydroxypenta(ne/o)nitrile **(1)** 5
or 1-cyanobutan-1-ol

(b) *Mechanism*

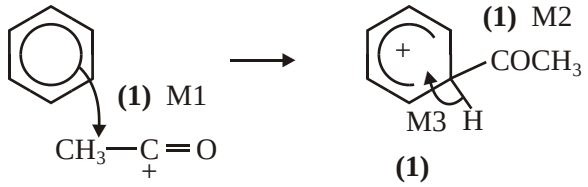



structure **(1)** M3
3 arrows **(1)** M4

*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 1p

(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

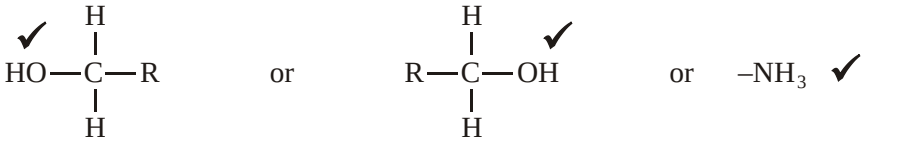
**[14]**

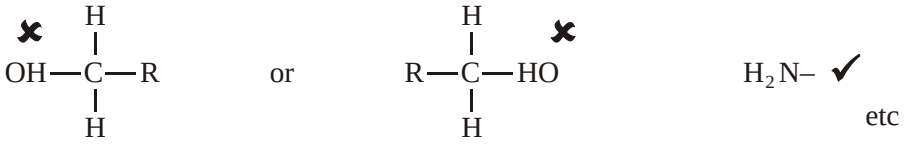
Organic points

(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. —C—) once per paper




Penalise once per paper

allow $CH_3$– or –$CH_3$ or $\begin{matrix}CH_3\\|\end{matrix}$ or $CH_3$

or $H_3C$–

**9.** (a) *Step 1*

acylation or electrophilic substitution **(1)**

$A1C1_3$ **(1)** $CH_3CH_2COCl$ <u>or</u> $(CH_3CH_2CO)_2O$ **(1)**

*Step 2*

reduction or hydrogenation **(1)**

$NaBH_4$ <u>or</u> $hiA1H_4$ <u>or</u> $Na/C_2H_5OH$ $H_2/N1$<u>or</u> Pt <u>or</u> Pd **(1)**

*Step 3*

dehydration <u>or</u> elimination **(1)**

$H_2SO_4$ <u>or</u> $H_3PO_4$ <u>or</u> $A1_2O_3$ **(1)** 7

(b) optical **(1)** 1

(c) geometrical or cis-trans isomers **(1)**

due to restricted rotation **(1)** 2

(d) (i)

$CHBrCH_2CH_3$ $CH_2CHBrCH_3$

**(1)** **(1)**

(ii) electrophilic addition **(1)**

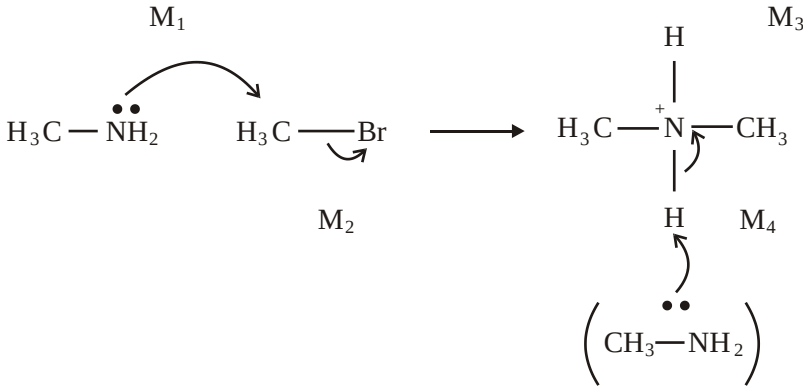
(iii) $C_6H_5\overset{+}{C}HCH_2CH_3$ **(1)** $C_6H_5CH_2\overset{+}{C}HCH_3$ **(1)**

both secondary but one is more stable **(1)** 6

**[16]**

**10.** (a) dimethylamine 1

(b) nucleophilic substitution 1

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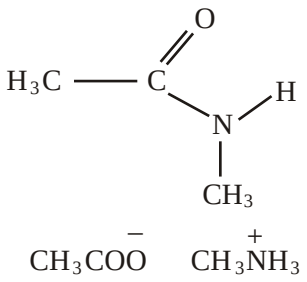
(c) quaternary ammonium salt 1

(cationic) surfactant / bactericide / detergent / fabric softener or conditioner/ hair conditioner 1

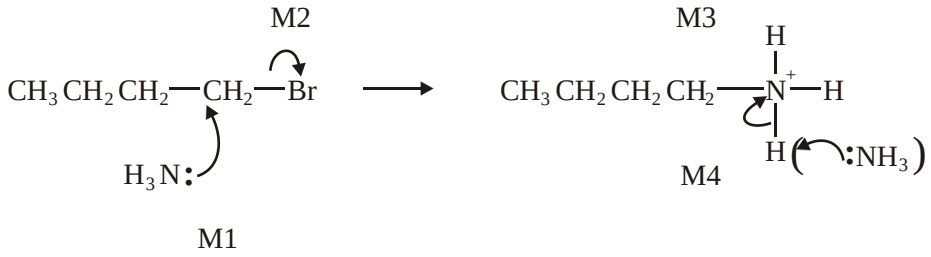
(d)



*(allow $CH_3COOH$ or $CH_3COO^-$ $NH4^+$)* 2

**[10]**

**11.** (a) Nucleophilic substitution 1




4

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 $H^+$)*

(b) Step 1 $CH_3CH_2CH_2CN$ 1

$CH_3CH_2CH_2Br + KCN \rightarrow CH_3CH_2CH_2CN + KBr$ balanced 1

(or $CN^-$) (or $Br^-$)

(*not HCN*) 1

Step 2 $CH_3CH_2CH_2CN + 2H_2 \rightarrow CH_3CH_2CH_2CH_2NH_2$ 1

(or 4[H])

(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) $CH_3CH_2N(CH_3)_2$ 1

**[12]**

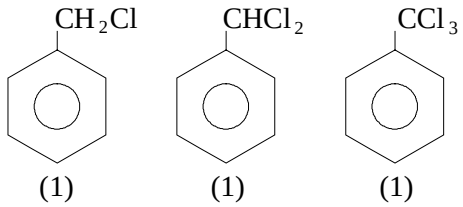
**12.** (a) (i) chloromethane, any halogenomethane (correct formula accepted) **(1)**

aluminium chloride / Fe / $FeCl_3$ /$BF_3$ **(1)**

anhydrous **(1)** 3

(ii) electrophilic **(1)**

substitution **(1)** 2

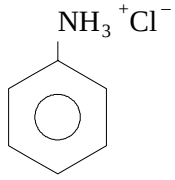
(b) 


(1) (1) (1)

and other correct products 3

penalise $C_6H_5$ once only

(c) (i) reduction / redox **(1)** 1

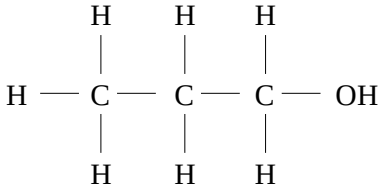
(ii) 

2

cation only, give 2

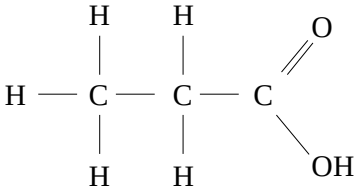
only phenylamine, give

salt correct with charges omitted, give 2

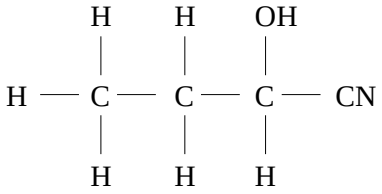
(d) (i) 

**(1)**

reduction / redox / hydrogenation / addition **not** electrophilic addition **(1)** 2

(ii) 

oxidation /redox **(1)** 2

(iii) 

**(1)**

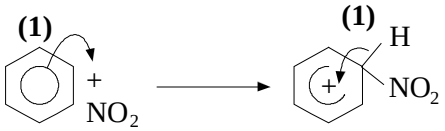
addition **not** electrophilic addition **(1)** 2

**[17]**

**13.** (a) $CHNO_3 + CH_2SO_4$ **(1)**

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

electrophilic substitution **(1)**




**(1)**

7

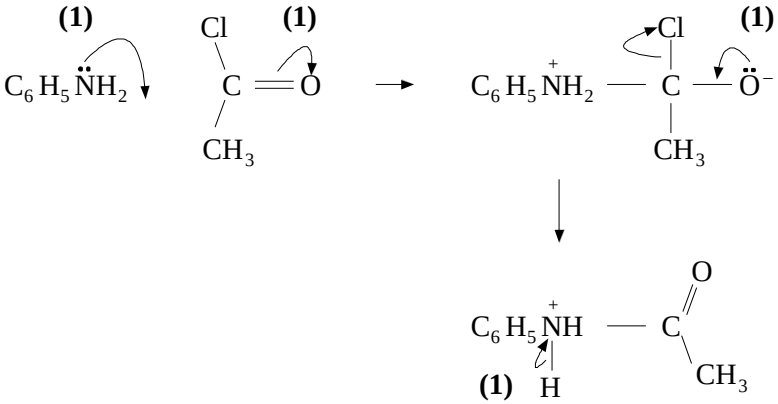
(b) reduction <u>or</u> hydrogenation **(1)**

HC1/Fe <u>or</u> Sn <u>or</u> Zn <u>or</u> Sn $Cl_2$ $H_2$/Ni <u>or</u> Pt <u>or</u> Pd <u>or</u> Cu **(1)** 2

(c) $C_6H_5NH_2 + CH_3\,COCl$ **(1)** $\rightarrow C_6H_5NHCOCH_3 + HCl$ **(1)**

<u>or</u> $C_6H_5NH_2 + (CH_3CO)_2O \rightarrow C_6H_5NH\,COCH_3 + CH_3\,COOH$

nucleophilic addition-elemination **(1)**

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**[16]**

**14.** (a) lone pair on N **(1)**

donated to $H^+$ <u>or</u> proton acceptor **(1)** 2

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

due to delocatisation **(1)** 2

(c) (i) nucleophilic substitution **(1)**

(ii) $(CH_3)_2\,NH$ **(1)**

$(CH_3)_3\,N$ **(1)**

$(CH_3)_4\,N+\,Br^-$ **(1)**

(iii) quaternary ammonium salt **(1)** 5

**[9]**

**15.** (a) (i) $CH_3CN + 4[H]$ (<u>or</u> $2H_2$) $\rightarrow$ $CH_3CH_2NH_2$ **(1)**

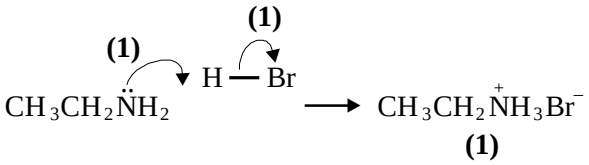
(ii) $LiAlH_4$ <u>or</u> $Na/C_2H_5OH$ (<u>or</u> $H_2/Ni$) **(1)** 2

(b) (nucleophilic) substitution <u>or</u> alkylation **(1)**

| *Product 1* | *Product 2* | *Product 3* |
|---|---|---|
| $(C_2H_5)_2NH$ | $(C_2H_5)_3N$ | $(C_2H_5)_4N^+Br^-$ |
| **(1)** | **(1)** | **(1)** |

4

(c)

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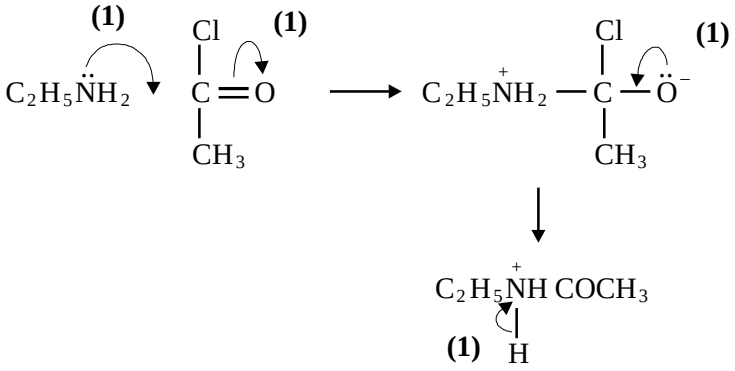
(d) lone pair on N less available
<u>or</u> electron density on N decreased **(1)**
due to delocalisation **(1)** 2

(e) electron withdrawal by O or CO
<u>or</u> delocalisation by CO **(1)** reduces electron
density on N <u>or</u> makes N lone pair less available **(1)** 2

(f) $2C_2H_5NH_2 + CH_3COCl$ **(1)** $\rightarrow$ $CH_3CONHC_2H_5 + C_2H_5NH_3^+Cl^-$ **(1)**
(nucleopholic) addition – elimination **(1)**

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**[20]**

**16.** (a) (i) H+ or proton acceptor **(1)**
$CH_3NH_2 + H_2O$ ($\rightleftharpoons$) $CH_3^+NH_3$ (+) $OH^-$ **(1)**

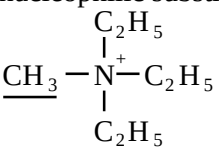
(ii) $CH_3NH_3Cl$ or HCl **(1)**
**Or any ammonium compound or strong acid name or formula**

(iii) extra $OH^-$ reacts with $CH_3\overset{+}{N}H_3$
or reaction / equilibrium moves to left
or ratio salt / base remains almost constant **(1)**
**Any 2**

5

(b) <u>lone pair</u> (on N accepts $H^+$) **(1)**
$CH_3$ increases electron density (on N)
donates / pushes electrons
has positive inductive effect **(1)** 2

(c) nucleophilic substitution **(1)**



**(1)** 2

**[9]**

**17.** (a) (i) *Equation* $C_6H_5CH_2Br + 2NH_3 \rightarrow C_6H_5CH_2NH_2 + NH_4Br$ **(1)**
**(1)**
*Type of reaction* nucleophilic subsn or alkylation **(1)**
*Explanation* further substitution occurs **(1)**
o give a mixture of products **(1)**

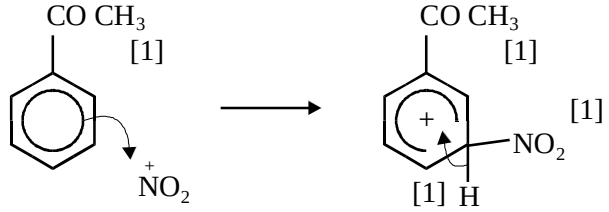
(ii) reduction or hydrogenation **(1)**
$C_6H_5CN + 4[H] \rightarrow C_6H_5CH_2NH_2$ **(1)**
or $2H_2$
$Na/C_2H_5OH$ or $LiAlH_4$ or $H_2/Ni$ **(1)**
only one product formed **(1)**
or avoids further substitution 9

(b) *Weaker* base phenylamine **(1)**
*Explanation* lone pair on N less available or electron density on N lowered **(1)**
due to delocalisation or overlap **(1)** 3

**[12]**

**18.** (a) (i) $cHNO_3 + cH_2SO_4$ **(1)**
$HNO_3 + 2H_2SO_4 \rightarrow NO_2^+$ **(1)** $+ H_3O^+ + 2HSO_4^-$ **(1)**

(ii) electrophilic substitution **(1)**

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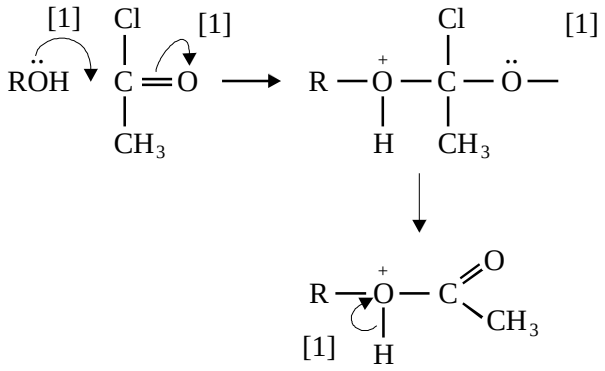
(b) *Type of reaction* reduction **(1)** not hydrogenation

*Reagent(s)* $NaBH_4$ or $Na/C_2H_5OH$ **(1)** not LiAlH4
not $H_2/Ni$ 2

(c) *Reagent* $CH_3COCl$ or $(CH_3CO)_2O$ **(1)**
*Name of mechanism* (nucleophilic addition–elimination **(1)**

*Mechanism*




6

(d) *Type of reaction* reduction <u>or</u> hydrogenation **(1)**
*Reagent(s)* HCl/Fe <u>or</u> Sn <u>or</u> Zn $H_2$/Ni <u>or</u> Pt <u>or</u> Pd **(1)**
<u>or</u> $SnCl_2$ <u>or</u> $Ni/H_2$

*<u>not</u> $LiAlH_4$* 2

(e) optical **(1)** 1

**[18]**

**19.** (a) (i) lone pair on N **(1)**

(ii) inductive effect of $CH_3$ <u>or</u> electron donation **(1)**
increases electron density on N
<u>or</u> lone pair more available **(1)**

(iii) electron density on N decreased
<u>or</u> lone pair less available **(1)**
due to delocalisation **(1)** 5

(b) (i) *Equation* $CH_3CH_2CN + 2H_2 \rightarrow CH_3CH_2CH_2NH_2$ **(1)**
*Catalyst* Ni **(1)**

(ii) nucleophilic substitution **(1)**

(iii) further reaction can occur **(1)**
between propylamine and 1-bromopropane **(1)** 5

(c) $CH_3CH_2CH_2NHCOCH_3$ **(1)** 1

(d) *Type of product* quaternary ammonium salt <u>or</u> chloride **(1)**
*Structural formula*

$CH_3(CH_2)_{11}N^+(CH_3)_3$ **(1)**
$Cl^-$ **(1)** 3

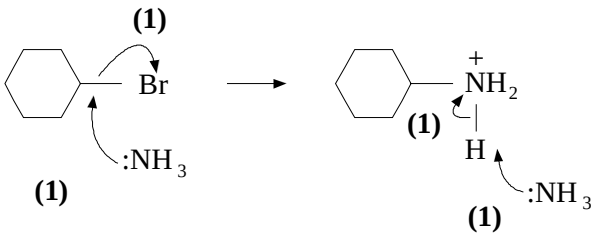
**[14]**

**20.** (a) Lone pair on nitrogen **(1)** less available <u>or</u>
electron density lowered **(1)** due to delocalisation <u>or</u>
resonance <u>or</u> mesomerism <u>or</u> part of x bond **(1)** 3

(b) *Equation* $C_6H_{11}Br + 2NH_3 \rightarrow C_6H_{11}NH_2 + NH_4Br$ **(1)**

*Name of mechanism* nucleophilic substitution **(1)**

*Mechanism*

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(c) (i) NaCN <u>or</u> KCN **(1)**

(ii) *Reagent(s)* $Na/C_2H_5OH$ <u>or</u> $LiAlH_4$ <u>or</u> $H_2/Ni$ **(1)**

*Type of reaction* reduction <u>or</u> hydrogenation **(1)**

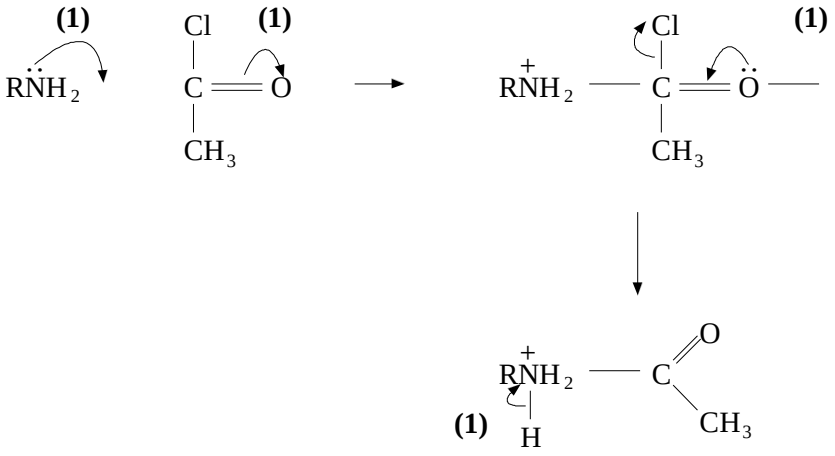
*Equation* $C_6H_{11}CN + 4[H] \rightarrow C_6H_{11}CH_2NH_2$ **(1)**
<u>or</u> $2H_2$ if hydrogenation

4

(d) *Equation* $2RNH_2 + CH_3COCl \rightarrow RNHCOCH_3$ **(1)** + $RNH_3Cl$ **(1)**

*Name of mechanism* (nucleophilic) addition-elimination **(1)**

*Mechanism*




7

**[20]**

**21.** (a) (i) suitable graphical formula for ethanoic anhydride **(1)** 1

(ii) (acid) anhydride **(1)** 1

(b) (i) **F =** ethylamine / aminoethane **(1)** 1

(ii) reduction **or** hydrogenation **or** addition (ignore reference to mechanism) **(1)**

1

(c) $CH_3COCl + CH_3CH_2NH_2 \rightarrow CH_3CONHCH_2CH_3 + HCl$

$CH_3CONHCH_2CH_3$ **(1)**

balanced **(1)** 2

**[6]**

**22.** (a) Lone pair on N <u>or</u> electron density on N **(1)**
more available <u>or</u> electron density increased **(1)**
electron donation <u>or</u> inductive effect **(1)** 3

(b) *Reagent(s)* $LiAlH_4$ <u>or</u> Na/EtOH <u>or</u> $H_2$/Ni **(1)**

*Type of reaction* reduction <u>or</u> hydrogenation **(1)**

*Equation* $CH_3CN + 4[H]$ <u>or</u> $2H_2 \rightarrow CH_3CH_2NH_2$ **(1)** 3

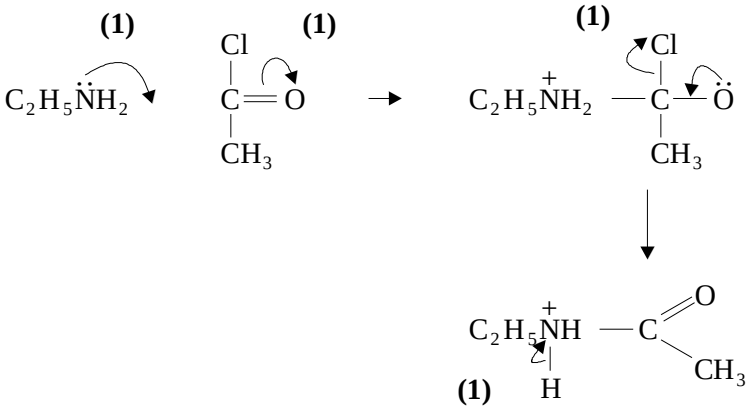
(c) $(C_2H_5)_4N^+Br^-$ **(1)**

quaternary ammonium salt **(1)**

cationic surfactant **(1)**
<u>or</u> fabric softener 3

(d) *Name of mechanism* addition-elimination **(1)**

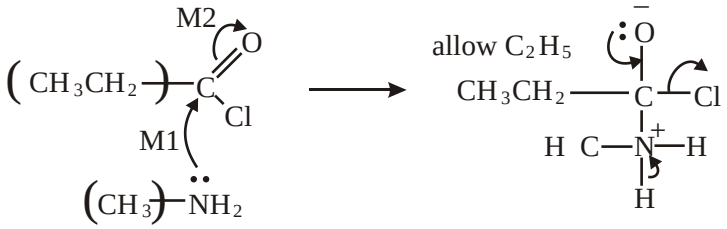
*Mechanism*


(1)
(1)
(1)
Cl
C
O
CH3
C2H5NH2
(1)
5

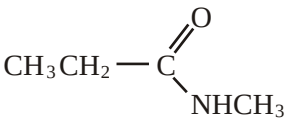
(e) $C_2H_5NH_2 + (CH_3CO)_2O \rightarrow C_2H_5NHCOCH_3 + CH_3COOH$ **(1)**
<u>or</u> $2C_2H_5NH_2 + (CH_3CO)_2O \rightarrow C_2H_5NHCOCH_3 + CH_3COO^- {}^+_N H_3C_2H_5$ 1

**[15]**

**23.** (a) (nucleophilic) addition-elimination; 1




*(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 $\delta$+ if correct)*
*($Cl^-$ removing Ft loses M4)*

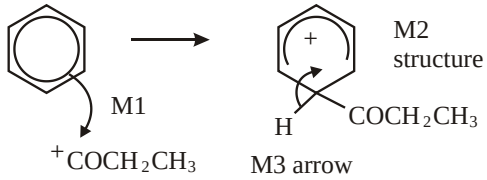


5

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

(b) $CH_3CH_2COCl + AlCl_3 \rightarrow [CH_3CH_2CO]^+ + AlCl_4^-$; 1

*(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 $AlCl_3$)*




*(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)*

*(M1 arrow from within hexagon to C or to + on C)*

*(don't penalise position of + on C of RCO+)*

*(allow M3 arrow independent of M2 structure)*

3

$AlCl_4^- + H^+ \rightarrow AlCl_3 + HCl$; 1

*(or can be gained in mechanism);*

(c) M1 $CH3CH2COCl + H2O \rightarrow CH3CH2COOH + HCl$ 1 — 1
*(penalise wrong alkyl group once at first error)*

M2 Mr of $CH3CH2COCl = 92.5$ 1 — 1
*(if Mr wrong, penalise M2 only)*

M3 moles of $CH3CH2COCl = 1.48/92.5 = 0.016$ 1 — 1

M4 moles $NaOH = 2 \times 0.016 = 0.032$ 1 — 1
*(allow for × 2 conseq to wrong no of moles)*

M5 volume of $NaOH = 0.032/0.42 = 0.0762$ dm3 or 76.2 cm3 1
*(with correct units)*
*(if ×2 missed in M4 lose M5 also)* — 1

**[16]**

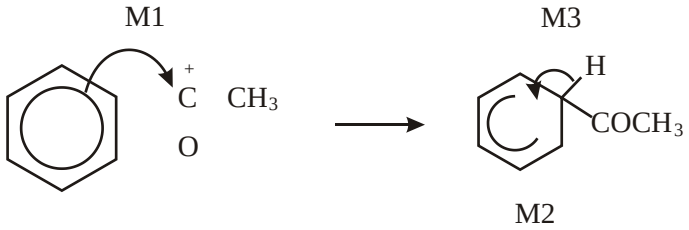
**24.** (a) $CH_3COCl + AlCl_3 \rightarrow CH_3\overset{+}{C}O + AlCl_4^-$ — 1

equation — 1

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 — 1

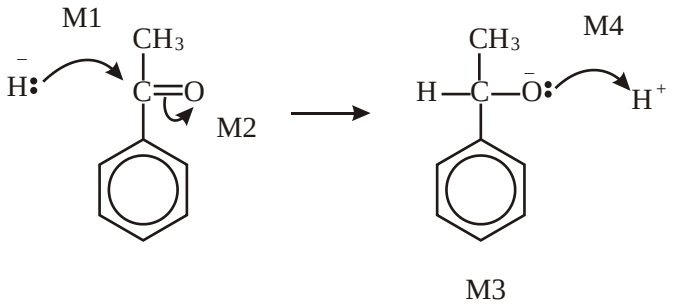
*NOT F/C acylation*




*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 RCO — 3

(b) Nucleophilic_addition NOT reduction 1




4

*M2 not allowed independent, but can allow M1 for attack of $H^-$ on C+ formed*

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

(c) dehydration or elimination 1

(conc) $H_2SO_4$ or (conc) $H_3PO_4$ 1

*allow dilute and $Al_2O_3$*

*Do not allow iron oxides*

**[14]**

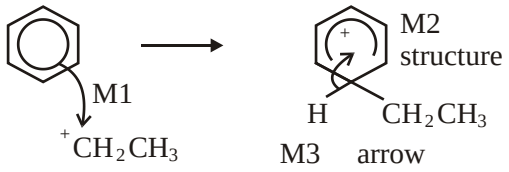
**25.** (a) ethyl benzene 1

chloroethane or bromoethane *(or ethene and hydrogen chloride/bromide)* 1

aluminium chloride/bromide or iron(III) chloride /bromide or iron + chorine/bromine 1

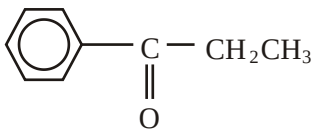
$CH_3CH_2Cl + AlCl_3 \rightarrow CH_3CH_2^+ + AlCl_4^-$ 1

electrophilic substitution 1




3

(b) 1




$CH_3CH_2COCl$ / propanoyl chloride or $(CH_3CH_2CO)_2O$ / propanoic anhydride 1

$NaBH_4$ or $LiAlH_4$ or $H_2$/Ni (*not Sn/Fe with HCl*) 1

**[11]**

**26.** **X** is $CH_3CN$ or ethanenitrile or ethanonitrile or methyl cyanide or cyanomethane or ethyl nitrile or methanecarbonitrile 1

***Not** ethanitrile*

*but contradiciton of name and structure lose marks*

**Y** is $CH_3CH_2NH_2$ or ethylamine or aminoethane or ethanamine 1

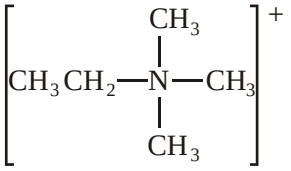
Step 1: reagent KCN not HCN/HCl 1

condition (aq)/alcohol - only allow condition if reagent correct or incomplete 1

| | | | | | | |
|---|---|---|---|---|---|---|
| Step 2: reagent | $H_2$ | $LiAlH_4$ | Na | Zn/Fe/Sn | Not $NaBH_4$ | 1 |
| condition | Ni/Pt/Pd | ether | ethanol | HCl | | 1 |

**Z** is an amine or aminoalkane or named amine even if incorrect name for **Z** 1

secondary (only award if amine correct)



$(Br^-)$ + can be on N or outside brackets as shown 1

nucleophilic substitution 1

**[9]**

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

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

360 – 208 = 152 kJ **(1)** NOT 150 4

*152 can score first 2*

*QofL: benzene lower in energy / <u>more</u> (stated) stable **(1)***

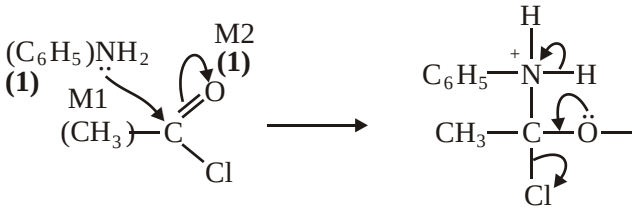
*Not award if mentions energy required for bond breaking*

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

(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)**

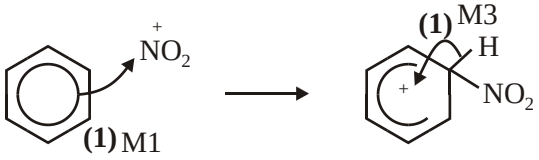



*structure **(1)** M3*
*3 arrows **(1)** M4*

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)**




**(1)** M2

6

(iv) peptide / amide **(1)**
NaOH (aq) **(1)** 2

*HCl conc or dil or neither*
*$H_2SO_4$ dil NOT conc*
*NOT just $H_2O$*

**Notes**

(a)
- 360 or 3 × 120 or in words **(1)**;
- 152 NOT 150 **(1)**; (152 can get first two marks)
- **Q of L** benzene <u>more</u> 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
C⟹O alone loses M2

(iii) **<u>No marks for name of mechanism in this part</u>**
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]**