M1.B

[1]

M2.D

[1]

M3.B

[1]

M4.D

[1]

M5.D

[1]

M6.C

[1]

M7.B

[1]

M8.A

[1]

M9.C

[1]

M1.B

[1]

M2.D

[1]

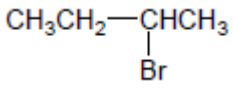
M3. Step 1

HBr

In any step, if wrong reagent or extra wrong reagent, can only score mechanism mark,but if $AlCl_3$ added in Step 3, lose M7 but can score M8 & M9

M1

1



M2

1

electrophilic addition

If 1-bromobutane structure given for M2 then 1-aminobutane structure for M5, penalise M2 and M5 but mark M8 consequentially

M3

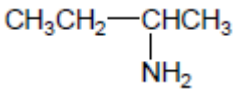
1

Step 2

NH_3

M4

1



If 1-bromobutane structure given for M2 then 2-aminobutane structure for M5, penalise M2, M5 and M8

M5

1

nucleophilic substitution

If 2-bromobutane structure given for M2 then 1-aminobutane structure, penalise M5 and M8

M6

1

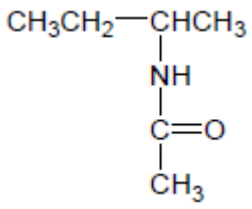
Step 3

CH_3COCl or $(CH_3CO)_2O$

Allow C_2H_5 for CH_3CH_2

M7

1



M8

1

(nucleophilic) addition-elimination

Not allow (electrophilic) addition-elimination

M9

1

[9]

M4.(a) Hydrogen bond(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) conc HNO_3

conc H_2SO_4

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

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

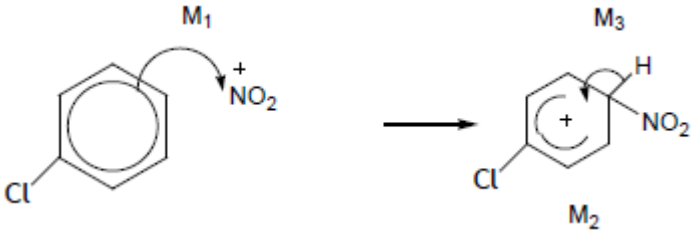
$H_2NO_3^+ \longrightarrow H_2O + NO_2^+$

Allow 1:1 equation.
$HNO_3 + H_2SO_4 \longrightarrow NO_2^+ + H_2O + HSO_4^-$.

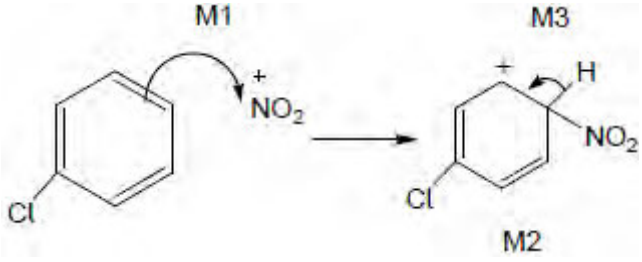
1

(iv) Electrophilic substitution

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) (i) Single reagent

If wrong single reagent, CE = zero

Incomplete single reagent (e.g. carbonate) or wrong formula (e.g.$NaCO_3$) loses reagent mark, but mark on

For "no reaction" allow "nothing"

Different reagents

If different tests on E and F; both reagents and any follow on chemistry must be correct for first (reagent) mark.
Reagent must react: i.e. not allow Tollens on G (ketone) – no reaction.
Second and third marks are for correct observations.
i.e. for different tests on E and F, if one reagent is correct and one wrong, can score max 1 for correct observation with correct reagent.

PCl_5 PCl_3

$SOCl_2$

1

E ester

Na_2CO_3/$NaHCO_3$ named carbonate

metal e.g.Mg

no reaction

no reaction

named indicator

no effect

No reaction

1

F acid

Na_2CO_3/$NaHCO_3$ named carbonate

Effervescence or CO_2

metal e.g.Mg

Effervescence or H_2

named indicator

acid colour

fumes

1

(ii) Single reagent

If wrong single reagent, CE = zero
Incomplete single reagent (e.g. carbonate) or wrong formula (e.g.$NaCO_3$) loses reagent mark, but mark on
For "no reaction" allow "nothing"

Different reagents

If different tests on E and F; **both** reagents and any follow on chemistry must be correct for first (reagent) mark.
Reagent must react: i.e. not allow Tollens on

G (ketone) – no reaction.
Second and third marks are for correct observations.

1

i.e. for different tests on E and F, if one reagent is correct and one wrong, can score max 1 for correct observation with correct reagent.

G ketone

$AgNO_3$

no reaction

Na_2CO_3/$NaHCO_3$ named carbonate

water

no reaction

named indicator

no effect

Named alcohol

no reaction

Named amine or ammonia

no reaction

1

H Acyl chloride

$AgNO_3$

(white) ppt

Na_2CO_3/$NaHCO_3$ named carbonate

Effervescence or CO_2 or fumes or exothermic

water

fumes

named indicator

acid colour

Named alcohol

Smell or fumes

Named amine or ammonia

fumes

1

Allow iodoform test or Brady's reagent (2,4,dnph) test (both positive for G)

(iii) Single reagent

If wrong single reagent, CE = zero
Incomplete single reagent (e.g. carbonate) or wrong formula (e.g.$NaCO_3$) loses reagent mark, but mark on

For "no reaction" allow "nothing"

Different reagents

If different tests on E and F; **both** reagents and any follow on chemistry must be correct for first (reagent) mark.

Reagent must react: i.e. not allow Tollens on G (ketone) – no reaction.

Second and third marks are for correct observations.

i.e. for different tests on E and F, if one reagent is correct and one wrong, can score max 1 for correct observation with correct reagent.

1

J Primary alcohol

$K_2Cr_2O_7$/ H^+

goes green

$KMnO_4$/ H^+

decolourised / goes brown

Lucas test ($ZnCl_2$/HCl)

Penalise missing H^+ but mark on

1

K Tertiary alcohol

$K_2Cr_2O_7$/ H^+

No reaction

$KMnO_4$/ H^+

no reaction

Lucas test ($ZnCl_2$/HCl)

Rapid cloudiness

1

If uses subsequent tests e.g. Tollens/Fehlings, test must be on product of oxidation

(b) (i) 3,3-dimethylbutan-1-ol

Allow 3,3-dimethyl-1-butanol

1

4

1

Triplet on three

1

(ii) 2-methylpentan-2-ol

Allow 2-methyl-2-pentanol

1

5

1

Singlet or one or no splitting

1

[15]

M6. Acidified potassium dichromate(VI)

1

Turns green with propan-2-ol and propanal

1

No reaction with hexene and 1-bromopropane

1

Tollens with propan-2-ol and propanal

only propanal gives silver mirror **1**

Bromine water **1**

Decolourised by hexane **1**

No reaction with 1-bromopropane **1**

Warm NaOH followed by acidified $AgNO_3$ **1**

White ppt with 1-bromopropane **1**

[10]

M7. In each section

- If wrong or no reagent given, no marks for any observations;
- Penalise incomplete reagent or incorrect formula – but mark observations
- Mark each observation independently
- Allow *no reaction* for no change / no observable reaction in all three parts, but not *none* or *nothing*
- Q says **one test**. If two tests are given, score zero

(a)

	$K_2Cr_2O_7$ / H^+	$KMnO_4$ / H^+	Lucas test ($ZnCl_2$ / HCl)
R Primary alcohol	(Orange) goes green Penalise wrong starting colour	(purple) goes colourless / decolourises allow goes brown	No cloudiness

1

1

S Tertiary alcohol	no change / no observable reaction	no change / no observable reaction	Rapid cloudiness

1

Allow acidified potassium manganate and acidified potassium dichromate without oxidation numbers

(b)

	Na_2CO_3 / $NaHCO_3$ named carbonate	metal eg Mg	named indicator

PCl_5 PCl_3
$SOCl_2$
Named alcohol + HCl / H_2SO_4

1

T ester	no change / no observable reaction	no change / no observable reaction	no effect

no change / no observable reaction

1

U Acid	Effervescence or (CO_2) gas formed	Effervescence or (H_2) gas formed	acid colour

Fumes / (HCl) gas formed
Sweet smell

1

(c)

	Fehling's / Benedict's	Tollens' / $[Ag(NH_3)_2]^+$	$K_2Cr_2O_7$/ H^+

I_2 / NaOH

1

V Ketone	no change / no observable reaction	no change / no observable reaction	no change / no observable reaction

Yellow ppt

1

W aldehyde	Red ppt	Silver mirror	(Orange) goes green Penalise wrong starting colour

no change / no observable reaction

1
[9]

M1.B

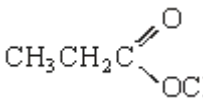
[1]

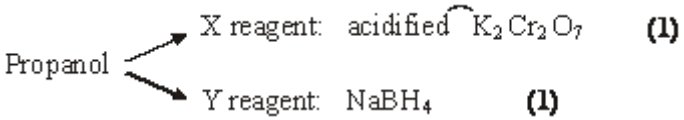
M2. (a) X contains > C=O **(1)**

if X and Y reversed lose this mark but allow remaining max 6/7

∴ X is CH_3CH_2COOH **(1)**

∴ Y is $CH_3CH_2CH_2OH$ **(1)**

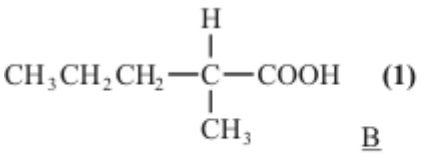
∴ A is  **(1)**



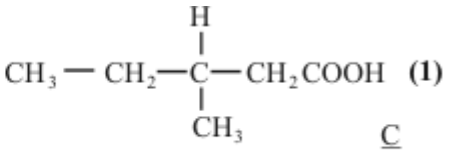
Conc H_2SO_4 : catalyst **(1)**

7

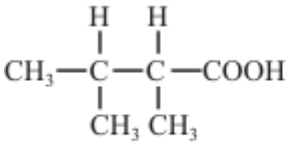
(b)

 **(1)**

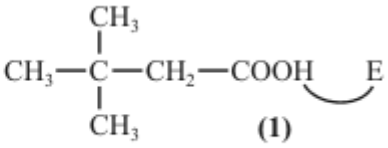
B

 **(1)**

C

 **(1)**

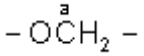
D

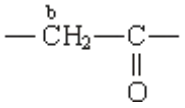
 **(1)**

E

in any order

4

(c)  3.1 – 3.9 **(1)**



2.1 – 2.6 **(1)**

a: quartet **(1)** ⌒ 3 adjacent H **(1)**

b: triplet **(1)** ⌒ 2 adjacent H **(1)**

6

(d) 3269 cm^{-1} ∴ OH ⌒ alcohol **(1)**



∴ G is (1)

2

Notes

(a) first mark for C=O stated or shown in **X**

Ignore wrong names

Y $CH_3CH_2CH_2OH$

allow C_3H_7 in **A** if **Y** correct or vice versa

Allow **(1)** for **A** if correct conseq to wrong **X** and **Y**

other oxidising agents: acidified $KMnO_4$; Tollens; Fehlings

other reducing agents: $LiAlH_4$; Na/ethanol; Ni/H_2; Zn or Sn or Fe/HCl

(b) give **(1)** for carboxylic acid stated or COOH shown in each suggestion
(1) for correct **E**
any 2 out of 3 for **B**, **C** or **D**
allow C_3H_7 for either the **B** or **D** shown on the mark scheme
i.e. a correct structure labelled **B**, **C** or **D** or **E** will gain 2.

(c) protons a – *quartet* must be correct to score *3 adjacent H* mark. Same for b

(d) allow **(1)** for any OH (alcohol) shown correctly in any structure – ignore extra functional groups. Structure must be completely correct to gain second mark

[19]

Organic points

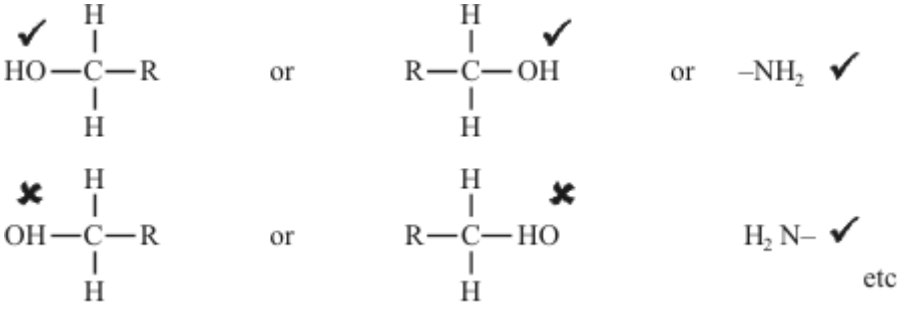
(1) Curly arrows: must show movement of a pair of electrons,
i.e. from bond to atom or from lp to atom / space

e.g.



(2) Structures

penalise sticks (i.e. ) once per paper



Penalise once per paper

allow CH_3– or –CH_3 or  or CH_3
or H_3C–

M3. D

[1]

M4. (a) $CH_3COCl + AlCl_3 \rightarrow CH_3\overset{+}{C}O + AlCl_4^-$
(1) equation (1)

2

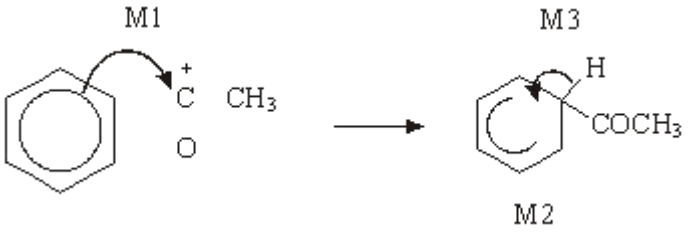
penalise wrong alkyl group once at first error
position of + on electrophile can be on O or C or outside [ ]

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

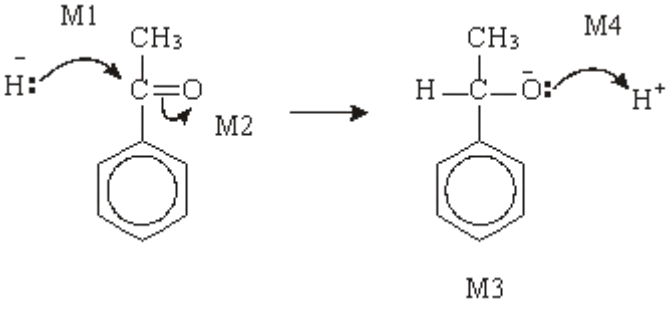
+ must be on C of $\overset{+}{R}CO$

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]

M5. **X** is CH_3CN or ethanenitrile or ethanonitrile or methyl cyanide or cyanomethane or ethyl nitrile or methanecarbonitrile

***Not** ethanitrile*

but contradiciton of name and structure lose marks

1

Y is $CH_3CH_2NH_2$ 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

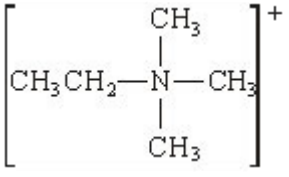
2

Step 2: reagent H_2 $LiAlH_4$ Na Zn/Fe/Sn Not $NaBH_4$
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^-) + can be on N or outside brackets as shown

1

nucleophilic substitution

1

[9]

M6. (a) (i)

Reagent	Tollens	Fehlings or Benedicts	$K_2Cr_2O_7/H^+$ or acidified	$KMnO_4/H^+$	I_2/NaOH
Propanal	silver (mirror)	red ppt or goes red *(not red solution)*	goes green	goes colourless	No reaction
Propanone	no reaction	no reaction	no reaction	no reaction	Yellow (ppt)

(penalise incomplete reagent e.g. $K_2Cr_2O_7$ or $Cr_2O_7^{2-}/H^+$ then mark on)

3

(ii) propanal 3 peaks

ignore splitting even if wrong

1

propanone 1 peak

1

(b) **X** is CH_3CH_2COOH or propanoic acid if both name and formula given, both must be correct, but

1

Y is $CH_3CH(OH)CH_3$ or propan-2-ol allow propanol with correct formula

1

Mark the type of reaction and reagent/condition independently.
The reagent must be correct or close to score condition

Step 1 Oxidation

$K_2Cr_2O_7/H^+$ or other oxidation methods as above
allow $Cr_2O_7^{2-}H^+$ if penalised above (ecf)
reflux (not Tollens/Fehlings) or heat or warm

1

Step 2	reduction or nucleophilic addition	reduction or nucleophilic addition	reduction or hydrogenation	
	$NaBH_4$	$LiAlH_4$	H_2	**1**
	in (m)ethanol or water or ether	ether or dry	Ni / Pt etc	**1**

or dry		

Step 3 esterification or (nucleophilic) addition-elimination or condensation **1**

(conc) H_2SO_4 or HCl **1**

warm (allow without acid reagent if **X** and **Y** given as reagents) **1**

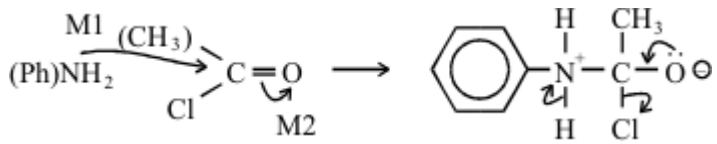
or reflux or heat **1**

[15]

M1. (a) CH_3COCl or $(CH_3CO)_2O$ **(1)**

$AlCl_3$ or H_2O or CH_2SO_4 loses this mark
CH_3COOH loses reagent and M3, M4 = max 3

nucleophilic addition–elimination **(1)**



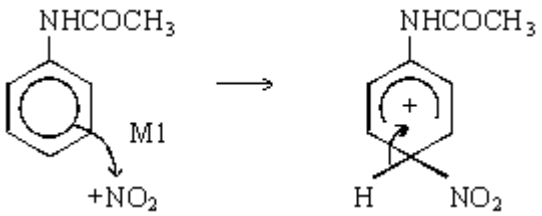
M3: structure
M4: 3 correct arrows
Allow M1 for attack on CH3 - C^+=O
Penalise Cl^- removing H^+

6

(b) Conc HNO_3 **(1)**
Conc H_2SO_4 **(1)**
$HNO_3 + 2\ H_2SO_4 \rightarrow NO_2^+ + H_3O^+ + 2\ HSO_4^-$ **(2)**
(or H_2SO_4) **(or H_2O + HSO_4^-)**

HNO_3 / H_2SO_4 scores 1
Any 2

electrophilic substitution **(1)**

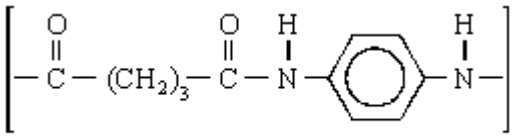


M2 structure
M3 arrow

6

(c) Sn **(or Fe)** / HCl or Ni / H_2 **(1)**

NOT $LiAlH_4$ $NaBH_4$



(1) **(1)**

3

[15]

M2.C

[1]

M3.A

[1]

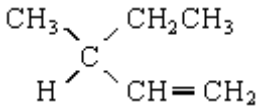
M4.B

[1]

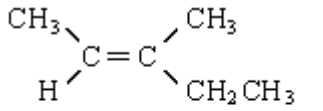
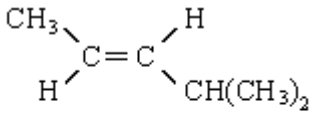
M5.C

[1]

M6. (a) *Structure of* **P**:


(1)

Structures of **Q** and **R**:


and


NOT C_3H_7

(1) **(1)**

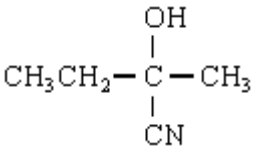
Q and R in any order

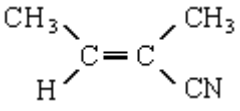
3

(b) (i) *Racemic mixture*: <u>equal</u> mixture of optical isomers / enantiomers
OR in explanation

Explanation: planar (>C=O) **(1)**
attack from either side is equally likely **(1)**

(ii) *Reagent **S***: HCN or (KCN / HCl **or** H_2SO_4) **(1)**

*Compound **T***:  **(1)**

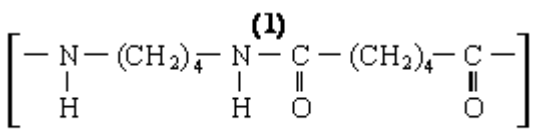
*Compound **U***:  **(1)**

6

[9]

M7.(a) 1, 4-diaminobutane or butane -1, 4-diamine **(1)**
A: $BrCH_2CH_2Br$ **or** $ClCH_2CH_2Cl$ **(1)**
B: $NC\ CH_2CH_2CN$
Step 1: Br_2 or Cl_2 **(1) (ignore aq)**
Step 2: KCN **(1) (NOT HCN)**
Step 3: H_2 / Ni **or** $LiAlH_4$ **or** Na / C_2H_5OH **(1) (NOT $NaBH_4$)**
Hydrogenation only for H_2 / Ni, **or** nucleophilic addition only for $LiAlH_4$**(1)**
OR reduction or addition

7

(b) 
(1)

(1)

QL hydrogen bonding **(1)**

Polarity of H-bonding shown or discussed **(1)**

4

(c) Polyamides / peptide link can be hydrolysed **(1)**

OR polyalkenes cannot be hydrolysed

QL $\underline{OH^-\text{ attacks}}$ peptide link or $C^{\delta+}$ **(1)**
poly(ethene) non-polar **(1)**

3

[14]

M8. D

[1]