AQA A-LEVEL CHEMISTRY · 7405

CHEMISTRY



MARK SCHEME

3.3.14 ORGANIC SYNTHESIS

SCORE	PERCENTAGE
/194	%

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Q1.

(a) 3-bromo-(2)-methylpropan-1-ol ONLY

3 and 1 are essential, 2 may be omitted, but any other number here is wrong

Ignore hyphens and commas

1

(b) Bromine is more electronegative than carbon

Allow difference in electronegativity if polarity of bond shown

M1

C is partially positive / electron deficient

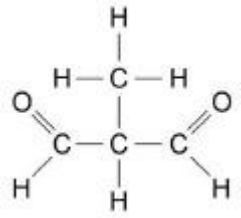
M2 and M3 can be awarded from diagram that shows nucleophilic attack

M2

Lone/electron pair (on the nucleophile) donated to the partially positive carbon

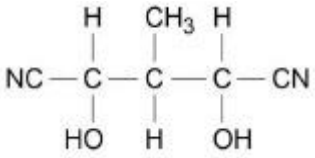
Allow lone pair attracted to / attacks the partially positive carbon

M3

(c) 

Must be displayed with all bonds shown

1

(d) 

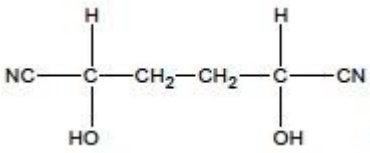
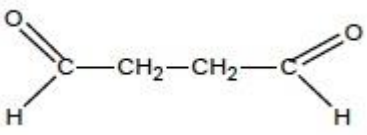
Not need be displayed

See General Marking instructions section 3.12 for penalties for incorrectly drawn bonds such as C–HO or C–NC etc.

1

KCN & (dil) acid

Allow

 from 

Allow HCN

Ignore alcoholic solvents

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Penalise conc. HCl, H_2SO_4 or any HNO_3

1

[7]

Q2.

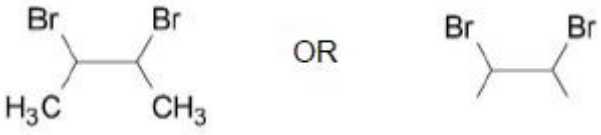
(a) 2,3-dimethylbutane(-1,4-)dioic acid

Penalise other numbers.

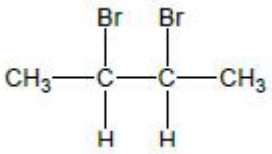
Ignore hyphens, commas, spaces.

1

(b)



Allow displayed formula



1

Step 1:

HBr

1

Electrophilic addition

1

Step 2:

KCN

Not HCN, not KCN with acid.

1

Nucleophilic substitution

1

Step 3:

Hydrolysis

1

(c)

	Mark
Reagent	1
Observation with **F**	1
Observation with	1

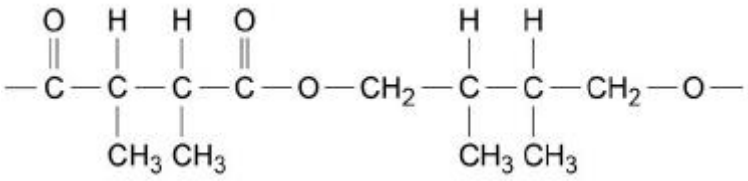
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G	

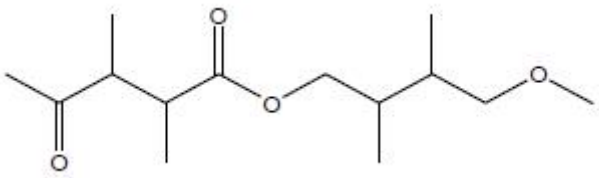
$K_2Cr_2O_7$ & H_2SO_4 (allow acidified)	**Mg**	**Na_2CO_3 or $NaHCO_3$**
F: no visible change	**F:** effervescence	**F:** effervescence
G: orange to green	**G:** no visible change	**G:** no visible change

Named alcohol and conc. sulfuric acid	**Named carboxylic acid and conc. sulfuric acid**
F: pleasant smell	**F:** no visible change
G: no visible change	**G:** pleasant smell

(d)



OR



Two ester groups.

1

One unit only.
Must have trailing bonds.
Ignore n and brackets.

1

(e) Mass of **G** = (1.11 × 10^3) cm^3 × 1.04 g cm^{-3} = 1154 g

65.1 scores 4 marks.

1

Amount of **G** $\frac{1154}{Mr = 118}$ = 9.78 mols

1

Amount of **F** (actual) = $\frac{930}{Mr = 146}$ =

6.37 mol

OR

Expected mass of **F** = 9.78 × (M_r =)

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146 = 1428 g

1

% yield = $\frac{6.37}{9.78}$ × 100 = 65.1(%)

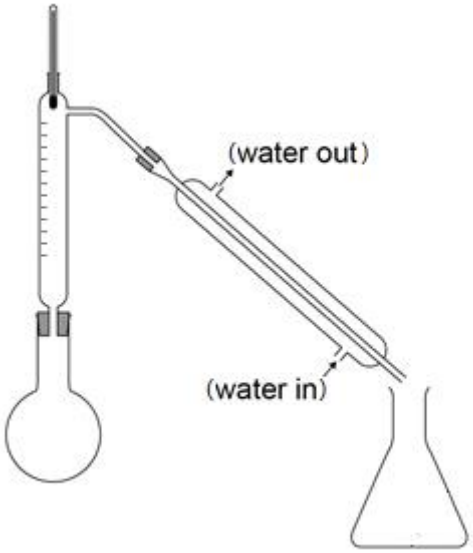
OR

% yield = $\frac{930}{1428}$ × 100 = 65.1(%)

M4 answer must be to 3 significant figures.

1

(f) Fractional distillation



A rough labelled sketch illustrating these points scores the marks.

1

Apparatus for fractional distillation must clearly work with fractionating column.

1

Fractionating column and thermometer.

1

Condenser / water jacket.

Ignore heat source.

1

[20]

Q3.

A

[1]

Q4.

(a) M1 NaOH

Only score M2 if M1 gained, but mark on from hydroxide.
Mention of acid loses M1 & M2

1

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M2 Aqueous/(warm)

Ignore alcoholic / conc / dil.

1

M3 (Fractional) distillation or described

Not just evaporation; not reflux

Allow chromatography

1

(b) M1 S is $CH_3CH(CN)CH_2CH_3$

Allow without brackets

1

Step 3

M2 KCN (mark on from CN^-)

Not HCN, not KCN with acid

1

M3 Alcoholic / (aqueous)

Allow ethanolic

Can only score M3 if M2 gained

1

Step 4

M4 H_2

$LiAlH_4$

Na

Can only score M5 if M4 gained

1

M5 Ni or Pt or Pd

Ethoxyethane or ether

$LiAlH_4$ with acid loses both M4 and M5

Ignore 'followed by acid'

Na

Ethanol

NOT $NaBH_4$ OR Sn/HCl

Penalise other extras as list

Ignore pressure or temperature

1

[8]

Q5.

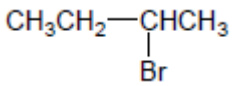
Step 1

HBr

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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

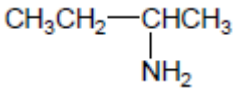
If 1-bromobutane structure given for M2 then 1-aminobutane structure for M5, penalise M2 and M5 but mark M8 consequentially

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

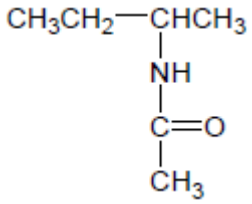
M6
1

Step 3

CH_3COCl or $(CH_3CO)_2O$

Allow C_2H_5 for CH_3CH_2

M7
1



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M8
1

(nucleophilic) addition-elimination

Not allow (electrophilic) addition-elimination

M9
1

[9]

Q6.

(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.

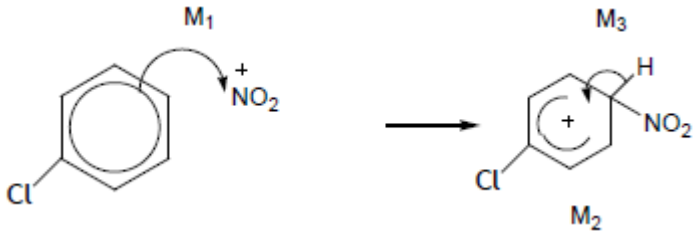
$HNO_3 + H_2SO_4 \longrightarrow NO_2^+ + H_2O + HSO_4^-$.

1

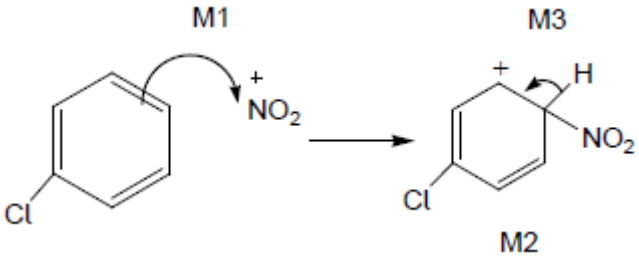
(iv) Electrophilic substitution

1

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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]

Q7.

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)

1

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R Primary alcohol	(Orange) goes green Penalise wrong starting colour	(purple) goes colourless / decolourises allow goes brown	No cloudiness

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

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1

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

no change / no observable reaction

1

[9]

Q8.

(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

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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

$AgNO_3$

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(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

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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]

Q9.

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

1

only propanal gives silver mirror

1

Bromine water

1

Decolourised by hexane

1

No reaction with 1-bromopropane

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

White ppt with 1-bromopropane **1**

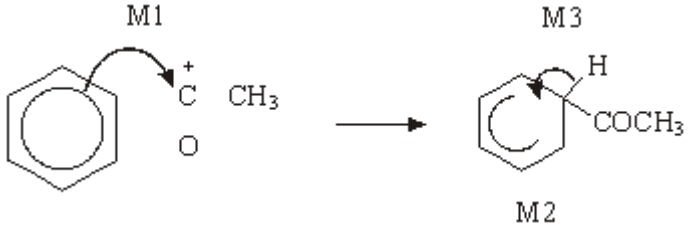
[10]

Q10.

(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**

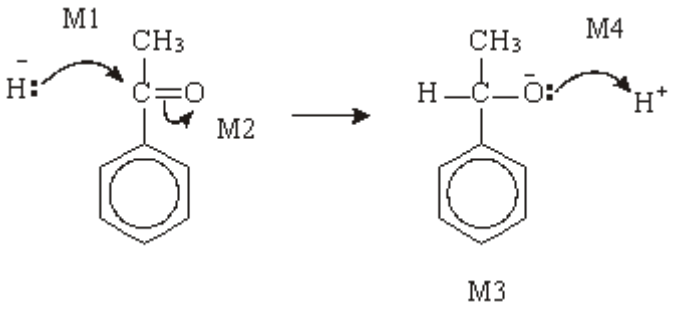


horseshoe must not extend beyond C2 to C6 but can be smaller
+ not too close to C1
M3 arrow into hexagon unless Kekule
allow M3 arrow independent of M2 structure

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

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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]

Q11.

B

[1]

Q12.

D

[1]

Q13.

(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

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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	1
	$NaBH_4$	$LiAlH_4$	H_2	1
	in (m)ethanol or water or ether or dry	ether or dry	Ni / Pt etc	1

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]

Q14.

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

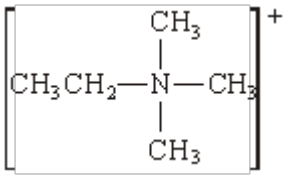
Step 2: reagent H_2 $LiAlH_4$ Na Zn/Fe/Sn Not $NaBH_4$
condition Ni/Pt/Pd ether ethanol HCl

2

Z is an amine or aminoalkane or named amine even if incorrect name for **Z** secondary (only award if amine correct)

1

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(Br⁻) + can be on N or outside brackets as shown

1

nucleophilic substitution

1

[9]

Q15.

D

[1]

Q16.

B

[1]

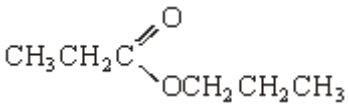
Q17.

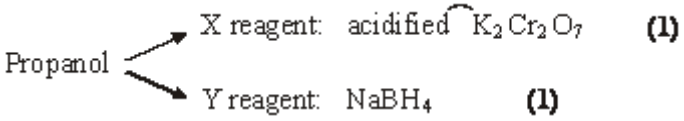
(a) X contains > C=O **(1)**

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)**

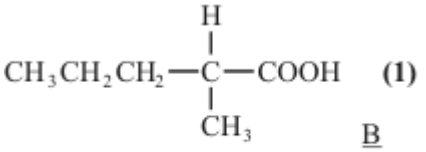
∴ A is  **(1)**

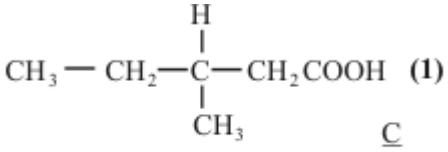


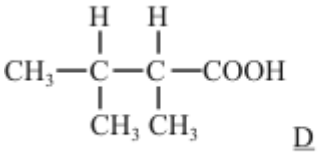
Conc H_2SO_4 : catalyst **(1)**

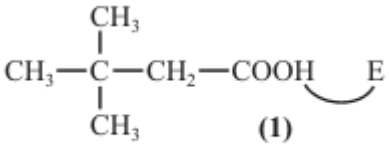
7

(b)

 **(1)** B

 **(1)** C

 **(1)** D

 E **(1)**

in any order

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4

(c) $-O\overset{a}{C}H_2-$ 3.1 – 3.9 **(1)**

$-\overset{b}{C}H_2-C(=O)-$ 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.

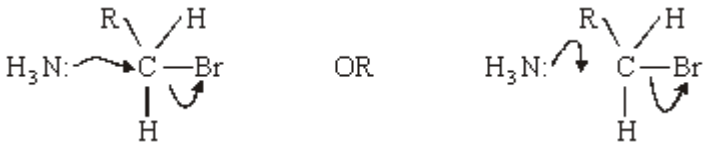
(c) protons a – *quartet* must be correct to score *3 adjacent H* mark. Same for b

(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

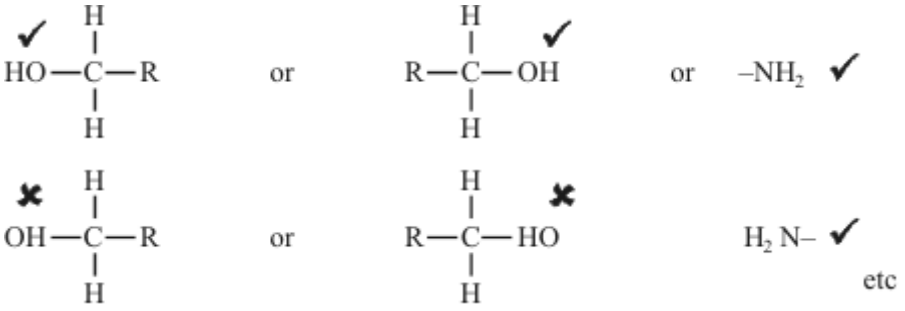
(1) Curly arrows: must show movement of a pair of electrons,
i.e. from bond to atom or from lp to atom / space
e.g.



(2) Structures

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penalise sticks (i.e. ) <u>once per paper</u>



<u>Penalise once per paper</u>

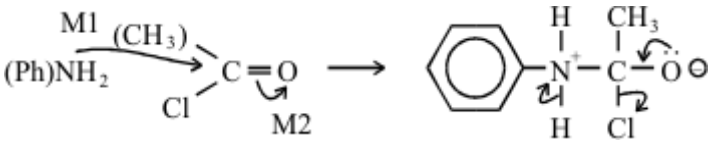
<u>allow</u> CH_3– or $–CH_3$ or  or CH_3
or H_3C–

Q18.

(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)**



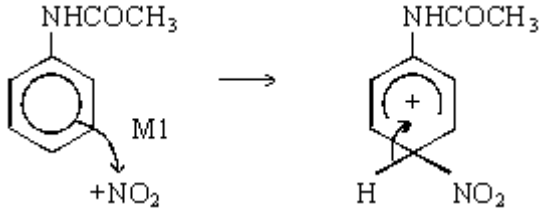
M3: structure
M4: 3 correct arrows
Allow M1 for attack on $CH3\text{-}C^{+}=O$
Penalise Cl^{-} removing H^{+}

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)**



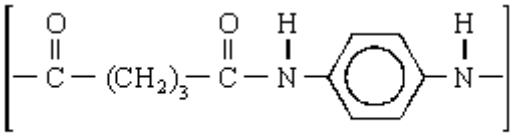
M2 structure
M3 arrow

6

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

NOT $LiAlH_4$ $NaBH_4$



(1) **(1)**

3

[15]

Q19.

D

[1]

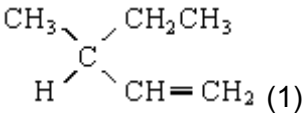
Q20.

C

[1]

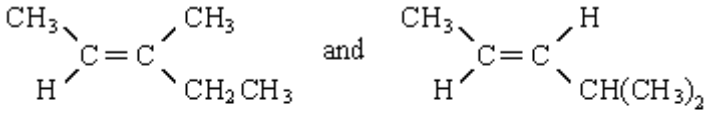
Q21.

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



(1)

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



(1) **(1)**

Q and R in any order

3

(b) (i) *Racemic mixture*: equal mixture of optical isomers / enantiomers

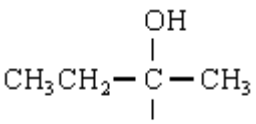
OR in explanation

Explanation: planar (>C=O) **(1)**

attack from either side is equally likely **(1)**

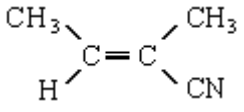
(ii) *Reagent **S***: HCN or (KCN / HCl **or** H_2SO_4) **(1)**

*Compound **T***:



(1)

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

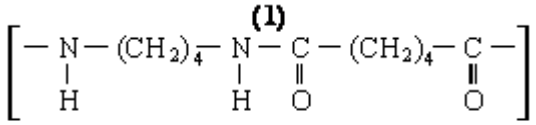
6

[9]

Q22.

(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)**

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

3

[14]

Q23.

B

[1]

Q24.

A

[1]

Q25.

C

[1]

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Q1.

(a) Most students correctly identified the main chain and the prefixes. However, only 40% gained the mark because of frequent errors in applying IUPAC rules in the numbering and alphabetical order of prefixes.

(b) The polarity of the bond between the bromine and the carbon, with the result that the carbon was slightly positive, was well known, although many struggled to explain this by a comparison of electronegativities. Some students failed to gain mark point 3 as they referred to nucleophiles as electron donors rather than electron pair donors, or simply stated that the nucleophile was attracted to the slightly positive carbon atom.

(c) This question was answered correctly by 39.4% of the students. Others identified the correct molecule but did not draw it as a displayed formula; $–CH_3$ was the most common error here. Some students drew an −OH group and a −C=O group in the same molecule, rather than two aldehyde groups; another common mistake was to draw butanedial.

(d) Most students identified that nitrile groups were present in this molecule, although some drew amines. There were some incorrectly drawn bonds, notably C–NC. Some who drew the incorrect butanedial in question 02.3 gained a mark here for a correct consequential structure. The reagent for Reaction **3** was not well answered. Many students missed the need for acid with KCN and some suggested the CN^- ion, which is an incomplete reagent.

Q4.

Most students knew that that the reagent was sodium hydroxide, but many did not know the correct conditions for its use in question (a). Incorrect answers included ‘concentrated’ or ‘dilute’ and the occasional ‘acidified’. The separation part of this question was answered well. In (b) the structure of compound **S** was frequently correct. The reagent and conditions in Step 3 were often confused and acidified KCN was a popular incorrect combination as was alcoholic HCN. In Step 4 most students correctly used hydrogen and a nickel catalyst, while others gained the marks for $LiAlH_4$ in ethoxyethane. Sadly some students who used $LiAlH_4$ included acidic conditions with the hydride and hence lost the marks. However, clearly stated use of acid after the reduction stage with $LiAlH_4$ was accepted.

Q5.

This question discriminated well with only the most able students able to score full marks. Steps 1 and 2 were generally well done but step 3 proved more of a challenge. The reagents in steps 1 and 2, HBr and NH_3, were well known, but wrong reagents were penalised as a chemical error and lost the product mark as well. A common error was to give 1-bromobutane as the product in step 1, and this chemical error earned a two mark penalty, but the product in step 3 could gain the mark consequentially.

Many students were unable to state a correct reagent in Step 3 and so could only access the mark for the mechanism in this step.

Q6.

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In part (b)(i), only the highest-scoring students gave the simplest correct answer in terms of the benzene repelling the nucleophile ammonia but alternative answers were allowed, including a comparison of the strength or polarity of the C–Cl bond in chlorobenzene with that in a haloalkane.

There was also some confusion between identifying regions of high electron density such as lone pairs and delocalised electrons, and referring to benzene and ammonia as being negatively charged. Some students also wrongly discussed further substitution. Part (b)(ii) was well answered. However, reagents were needed in full, so Sn with HCl was required not just H^+. Parts (b)(iii) and (iv) were also well answered. In part (b)(iii), 'concentrated' was needed with both acids to gain two marks, and M3 was often lost for the charge missing on $H_2NO_3^+$. The electrophilic substitution mechanism was generally well done although the positioning of the horseshoe representing delocalised electrons caused some problems in this example where the substitution did not occur at the carbon at the "top" of the benzene ring.

Q7.

This question was answered well with about two thirds of students scoring full marks. Common errors included incomplete reagents, such as omitting the acid used with potassium dichromate and giving just the name of the product without any observation as required.

Q8.

Part (a) was often interpreted badly, leading to fewer correct answers than usual for this type of question. Candidates often unnecessarily performed two separate tests or chose to do a follow-up test when a single test would have distinguished between the two substances. This created greater opportunity for chemical errors to arise. Many candidates failed to recognise F as an acid and K as a tertiary alcohol.

Although there were many correct answers in part (b), others were poorly expressed. Use of hydroxy rather than ol in the names and omission of di- in part (b)(i) were common mistakes.

Q10.

Part (a) was well answered and many candidates scored highly. The mechanism in part (b) proved more difficult and some candidates tried to use BH_4^- instead of H^- as expected. The name of the product proved very difficult for most candidates and many made no attempt to answer the question. In part (c), many confused Reaction 3, which is a dehydration or an elimination of water, with the removal of hydrogen from ethylbenzene using iron oxides.

Q13.

Part (a) was answered well. Most candidates were able to describe a correct chemical test to distinguish between the aldehyde, propanal, and the ketone, propanone. However, many thought that propanone had two peaks in its proton n.m.r. spectrum.

In part (b), better candidates had no difficulty in identifying propanoic acid as **X** and propan-2-ol as **Y** and in giving correct descriptions of oxidation in Step 1, reduction in Step 2 and esterification in Step 3. Weaker candidates lost marks for incorrect reagents or for wrong or missing conditions in the reactions.

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Q14.

Many candidates were able to draw correct structures for Compounds **X** (ethanenitrile) and **Y** (ethylamine), but some unfortunately then named them incorrectly. KCN not HCN was the required reagent in Step 1 in aqueous/alcoholic conditions. Several different reducing agents were allowed in Step 2, but hydrogen with a nickel catalyst was the most common correct answer. Many candidates thought that **Z** was an amide rather than a secondary amine. Only the better candidates were able to draw the correct structure of the quaternary ammonium salt formed by reaction of **Z** with an excess of bromomethane in a series of nucleophilic substitution reactions.

Q17.

This question discriminated well. Able candidates scored well in all parts, with part (b) found the most difficult. In part (a), oxidation and reduction of propanal were well understood and propanoic acid and propan-1-ol were identified by most except the least able.

Details of the oxidising and reducing agents were less secure and the role of sulphuric acid was not well known. In part (b), many candidates stated that all four isomers, **B**, **C**, **D** and **E** must be carboxylic acids but then drew structures which were not all acids. The structure of **E** was found to be the most difficult to deduce. In part(c) the splitting patters were well explained by many candidates, but the number who could correctly predict the δ values for the labelled protons was much smaller. In part(d), most were able to state that isomer **G** contained an alcoholic OH group, but only the most able could draw the correct structure for **G**.

Q18.

Full marks were scored in this question by many of the better candidates. In part (a), however, many other candidates confused the use of ethanoyl chloride in a Friedel Crafts electrophilic substitution with its role in a nucleophilic addition-elimination reaction with an amine. Hence the appearance of $AlCl_3$ as a catalyst or reagent was penalised.

The drawing of mechanisms as usual provides good discrimination and the better candidates often give beautifully presented answers. However red ink should not be used even in these mechanisms.

The electrophilic substitution in part (b) was answered very well. The main errors in the mechanism were the careless drawing of the horseshoe or the incorrect placing of the positive charge in the Wheland intermediate.

Part (c) was also answered well. All but the weakest could identify a correct reducing agent and were able to draw the repeating unit of the polymer formed by the acid $HOOC(CH_2)_3COOH$ with 1,4-diaminobenzene.

Q21.

This question was found difficult by many candidates and some marks were lost by candidates who did not read the question carefully. The second line of the question stated that P, Q and R were all branched-chain molecules, but many answers included unbranched isomers. Part (b) was better answered, but again the question asked for the reason a racemic mixture was formed and many answers contained only a description of what a racemic mixture is. Part (c) was found to be difficult and only the most able candidates gained all three marks here.

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Q22.

This question was found difficult by many candidates. The synthetic route in part (a) ended with butane-1,4-diamine and many candidates were able to deduce that Compound **B** was
$NC–CH_2CH_2–CN$ which would be reduced or hydrogenated to produce butane-1,4-diamine. To form $NC–CH_2CH_2–CN$ in two steps from ethene was found more difficult. The use of hydrogen bromide or even hydrogen were suggested as reagents with ethene by many candidates who forgot that a CN group was required at both ends of the molecule. An appreciable number of candidates also wrote equations and mechanisms in this question, when only reagents and structures were required. This used up precious minutes of their exam time for no reward.

In part (b), the repeating unit of the polyamide was deduced well, although some candidates drew nylon (6,6) rather than the polymer required. A brief statement to show that the chains were linked by hydrogen bonding was then all that was required. Details of the secondary structure of peptides was not necessary. Part (b) was worth 4 marks in total so candidates should be aware that they should spend only about 4 minutes on their answer.

In part (c) many answers contained details of the type of polymerisation involved in the formation of these polymers rather than the explanation that the non-polar polyalkenes are not attacked by hydroxide ions and are therefore not hydrolysed.

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