Q10.

The N-substituted amide $C_6H_{13}NO$ can be formed from but−2−ene in a three-step synthesis.

$$H_3CCH{=}CHCH_3 \xrightarrow{\text{Reaction 1}} C_4H_9Br \xrightarrow{\text{Reaction 2}} C_4H_{11}N \xrightarrow{\text{Reaction 3}} C_6H_{13}NO$$

For each reaction

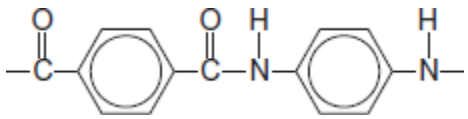
- state a reagent
- give the structure of the product
- name the mechanism of the reaction.

Detailed mechanisms are **not** required.

(Total 9 marks)

Q11.

Kevlar is a polymer used in protective clothing.
The repeating unit within the polymer chains of Kevlar is shown.



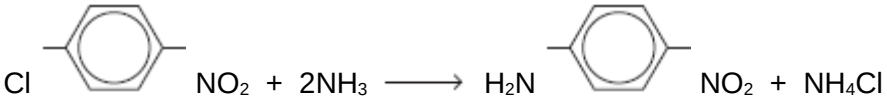
(a) Name the strongest type of interaction between polymer chains of Kevlar.

(1)

(b) One of the monomers used in the synthesis of Kevlar is

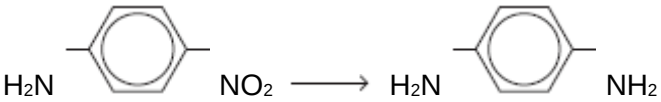
An industrial synthesis of this monomer uses the following two-stage process starting from compound **X**.

Stage **1**



X

Stage **2**



(i) Suggest why the reaction of ammonia with **X** in Stage **1** might be considered unexpected.

_____

_____

_____

_____

(2)

(ii) Suggest a combination of reagents for the reaction in Stage **2**.

_____

(1)

(iii) Compound **X** can be produced by nitration of chlorobenzene.

Give the combination of reagents for this nitration of chlorobenzene.
Write an equation or equations to show the formation of a reactive intermediate from these reagents.

Reagents _____

_____

Equation(s) _____

_____

(3)

(iv) Name and outline a mechanism for the formation of **X** from chlorobenzene and the reactive intermediate in part (iii).

Name of mechanism _____

Mechanism

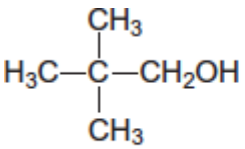
(4)
(Total 11 marks)

Q12.

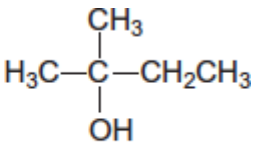
Describe how you could distinguish between the compounds in the following pairs using **one** simple test-tube reaction in each case.

For each pair, identify a reagent and state what you would observe when both compounds are tested separately with this reagent.

(a)



R



S

Reagent _____

Observation with **R** _____

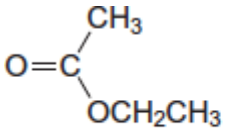
_____

Observation with **S** _____

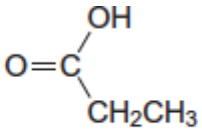
_____

(3)

(b)



T



U

Reagent _____

Observation with **T** _____

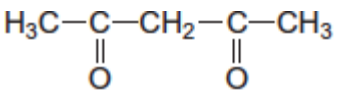
_____

Observation with **U** _____

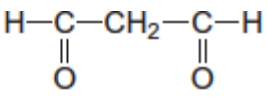
_____

(3)

(c)



V



W

Reagent _____

Observation with **V** _____

_____

Observation with **W** _____

_____

(3)

(Total 9 marks)

Q13.

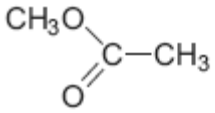
Organic chemists use a variety of methods to distinguish between compounds. These methods include analytical and spectroscopic techniques.

(a) The following compounds can be distinguished by observing what happens in test-tube reactions.

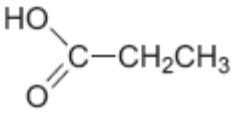
For each pair, suggest a suitable reagent or reagents that could be added separately to each compound in order to distinguish them.

Describe what you would observe with each compound.

(i)



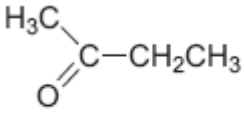
E



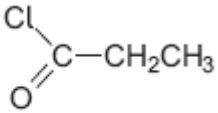
F

(3)

(ii)



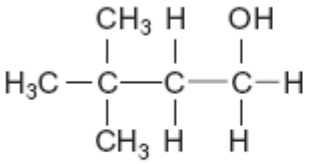
G



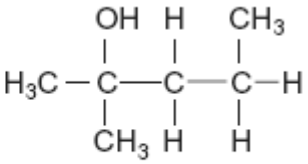
H

(3)

(iii)



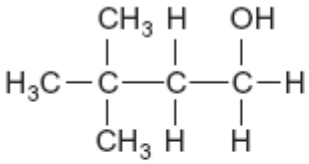
J



K

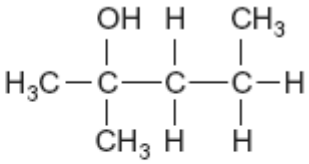
(3)

(b) Compounds **J** and **K** can also be distinguished using spectroscopic techniques such as ^{1}H n.m.r.



a

J



b

K

(i) Name compound **J**.

Give the total number of peaks in the ^{1}H n.m.r. spectrum of **J**.

State the splitting pattern, if any, of the peak for the protons labelled *a*.

(3)

(ii) Name compound **K**.

Give the total number of peaks in the ^{1}H n.m.r. spectrum of **K**.

State the splitting pattern, if any, of the peak for the protons labelled *b*.

(3)

(Total 15 marks)

Q14.

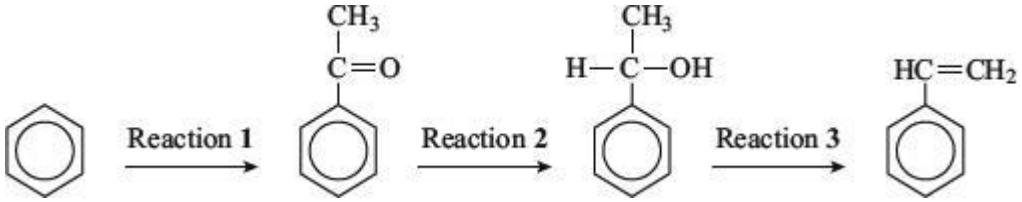
A chemist has discovered that the labels have fallen off four bottles each of which contains a different organic liquid. These liquids are known to be propan-2-ol, propanal, hexene and 1-bromopropane.

Suggest a series of test-tube reactions which a chemist could use to confirm the identities of the four compounds. State the reagents used and the observations expected.

(Total 10 marks)

Q15.

A possible synthesis of phenylethene *(styrene)* is outlined below.



(a) In Reaction **1**, ethanoyl chloride and aluminium chloride are used to form a reactive species which then reacts with benzene.
Write an equation to show the formation of the reactive species.
Name and outline the mechanism by which this reactive species reacts with benzene.

(6)

(b) $NaBH_4$ is a possible reagent for Reaction **2**.
Name and outline the mechanism for the reaction with $NaBH_4$ in Reaction **2**.
Name the product of Reaction **2**.

(6)

(c) Name the type of reaction involved in Reaction **3** and give a reagent for the reaction.

(2)

(Total 14 marks)

Mark Scheme

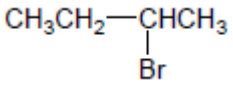
Q10.

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

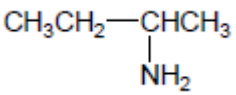
If 1-bromobutane structure given for M2 then 1-aminobutane structure for M5, penalise M2 and M5 but mark M8 consequentially

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

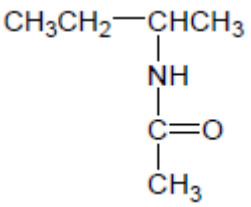
M6
1

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]

Q11.

(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

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

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

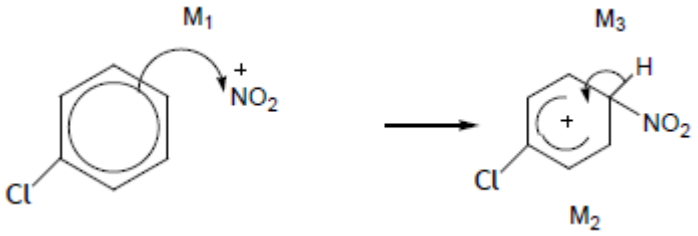
Allow 1:1 equation.

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

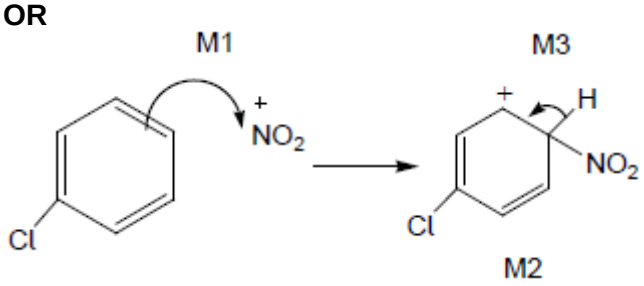
1

(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 + on N.*
- *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]

Q12.

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

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

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

Yellow ppt

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

no change / no observable reaction

1

1

1

[9]

Q13.

(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]

Q14.

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

1

Warm NaOH followed by acidified $AgNO_3$

1

White ppt with 1-bromopropane

1

[10]

Q15.

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

(1) equation (1)

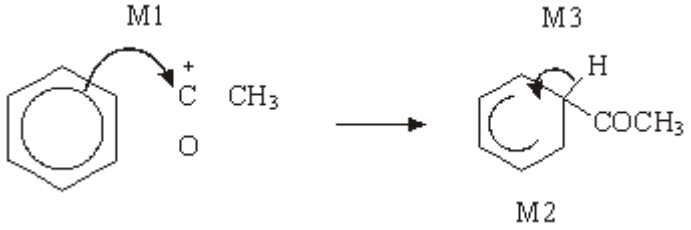
2

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

+

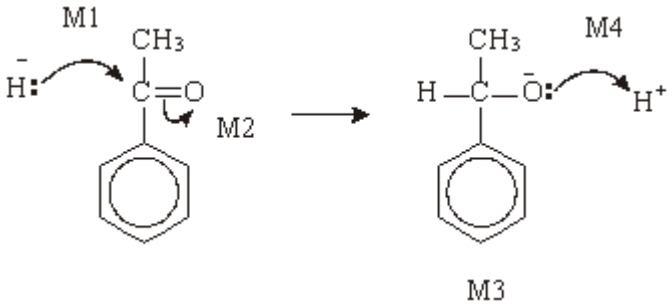
+ must be on C of RCO

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]