

**Q16.**

Suggest **one** reason why Tollens' reagent is used as the oxidising agent in the specific test for aldehydes rather than the less expensive acidified potassium dichromate(VI).

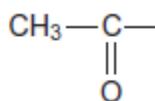
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(Total 1 mark)

**Q17.**

The triiodomethane reaction is often used as a test for aldehydes and ketones that contain the  $\text{CH}_3\text{CO}$  group shown.



The aldehyde or ketone is reacted with an alkaline solution of iodine. Triiodomethane ( $\text{CHI}_3$ ) is formed as a precipitate. Compounds that contain a group that can be oxidised to the  $\text{CH}_3\text{CO}$  group will also give a positive result in this test.

- (a) State, with a reason, whether or not ethanol will give a positive result in the triiodomethane reaction.

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(1)

- (b) The equation for the reaction of ethanal with an alkaline solution of iodine is



In an experiment using this reaction, the yield of triiodomethane ( $\text{CHI}_3$ ) obtained by a student was 83.2%.

Calculate the minimum mass of iodine that this student would have used to form 10.0 g of triiodomethane.

Give your answer to the appropriate precision.

Show your working.

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(5)

- (c) Triiodomethane can be separated from the reaction mixture by filtration.  
State **one** reason why the solid residue is then washed with water after the filtration.

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(1)

- (d) State **one** reason, other than cost or availability, why water is suitable for washing this solid residue after the filtration.

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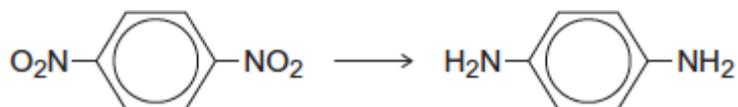
(1)

**(Total 8 marks)**

**Q18.**

Each of the following conversions involves reduction of the starting material.

(a) Consider the following conversion.



Identify a reducing agent for this conversion.

Write a balanced equation for the reaction using molecular formulae for the nitrogen-containing compounds and [H] for the reducing agent.

Draw the repeating unit of the polymer formed by the product of this reaction with benzene-1,4-dicarboxylic acid.

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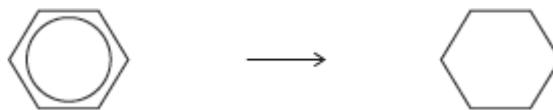
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(5)



- (b) Consider the following conversion.



Identify a reducing agent for this conversion.

State the empirical formula of the product.

State the bond angle between the carbon atoms in the starting material and the bond angle between the carbon atoms in the product.

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(4)

- (c) The reducing agent in the following conversion is  $\text{NaBH}_4$



- (i) Name and outline a mechanism for the reaction.

Name of mechanism \_\_\_\_\_

Mechanism

(5)



- (ii) By considering the mechanism of this reaction, explain why the product formed is optically inactive.

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(3)

(Total 17 marks)

### Q19.

Chemists have to design synthetic routes to convert one organic compound into another.

Propanone can be converted into 2-bromopropane by a three-step synthesis.

Step 1: propanone is reduced to compound **L**.

Step 2: compound **L** is converted into compound **M**.

Step 3: compound **M** reacts to form 2-bromopropane.

Deduce the structure of compounds **L** and **M**.

For each of the three steps, suggest a reagent that could be used and name the mechanism.

Equations and curly arrow mechanisms are **not** required.

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(Total 8 marks)

**Q20.**

(a) Propanoic acid can be made from propan-1-ol by oxidation using acidified potassium dichromate(VI). Propanal is formed as an intermediate during this oxidation.

(i) State the colour of the chromium species after the potassium dichromate(VI) has reacted.

\_\_\_\_\_

(1)

(ii) Describe the experimental conditions and the practical method used to ensure that the acid is obtained in a high yield. Draw a diagram of the assembled apparatus you would use.

Conditions \_\_\_\_\_

\_\_\_\_\_

Apparatus

(4)

(iii) Describe the different experimental conditions necessary to produce propanal in high yield rather than propanoic acid.

\_\_\_\_\_

\_\_\_\_\_

(2)

(b) Propan-1-ol is a volatile, flammable liquid.  
Give **one** safety precaution that should be used during the reaction to minimise this hazard.

\_\_\_\_\_

(1)

(c) A student followed the progress of the oxidation of propan-1-ol to propanoic acid by extracting the organic compounds from one sample of reaction mixture.

(i) Give a chemical reagent which would enable the student to confirm the presence of propanal in the extracted compounds.  
State what you would observe when propanal reacts with this reagent.

Reagent \_\_\_\_\_

Observation \_\_\_\_\_

\_\_\_\_\_

(2)



- (ii) Give a chemical reagent that would enable the student to confirm the presence of propanoic acid in the extracted compounds.  
State what you would observe when propanoic acid reacts with this reagent.

Reagent \_\_\_\_\_

Observation \_\_\_\_\_

\_\_\_\_\_

(2)

- (d) Predict which **one** of the compounds, propan-1-ol, propanal and propanoic acid will have the highest boiling point. Explain your answer.

Prediction \_\_\_\_\_

Explanation \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

(3)

(Total 15 marks)

### Q21.

Many synthetic routes need chemists to increase the number of carbon atoms in a molecule by forming new carbon-carbon bonds. This can be achieved in several ways including

- reaction of an aromatic compound with an acyl chloride
- reaction of an aldehyde with hydrogen cyanide.

- (a) Consider the reaction of benzene with  $\text{CH}_3\text{CH}_2\text{COCl}$

- (i) Write an equation for this reaction and name the organic product.  
Identify the catalyst required in this reaction.  
Write equations to show how the catalyst is used to form a reactive intermediate and how the catalyst is reformed at the end of the reaction.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

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(5)



- (ii) Name and outline a mechanism for the reaction of benzene with this reactive intermediate.

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(4)

- (b) Consider the reaction of propanal with HCN

- (i) Write an equation for the reaction of propanal with HCN and name the product.

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(2)

- (ii) Name and outline a mechanism for the reaction of propanal with HCN

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(5)



- (iii) The rate-determining step in the mechanism in part (b) (ii) involves attack by the nucleophile.  
Suggest how the rate of reaction of propanone with HCN would compare with the rate of reaction of propanal with HCN  
Explain your answer.

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**(2)**

**(Total 18 marks)**







## Mark Scheme

### Q16.

Dichromate(VI) will also oxidise / give a positive test with alcohols

*Allow 'dichromate'.*

*Allow 'dichromate(VI) will oxidise other organic molecules / functional groups'.*

[1]

### Q17.

(a) Yes, because it is oxidised to ethanal / CH<sub>3</sub>CHO

**OR** it is oxidised to a compound that contains CH<sub>3</sub>CO group

*Ignore 'primary alcohols are oxidised to aldehydes'.*

*Need 'yes' and an explanation to be awarded the mark.*

1

(b)  $M_r \text{ CHI}_3 = 393.7$  (**M1**)

*Allow if clearly shown in a calculation.*

*Allow 394*

1

Moles CHI<sub>3</sub> =  $10 / 393.7 = 2.54 \times 10^{-2}$  (**M2**)

*Allow a consequential answer on an incorrect  $M_r$ .*

*$2.54 \times 10^{-2}$  scores **M1** and **M2**.*

1

Moles I<sub>2</sub> =  $7.62 \times 10^{-2}$  (**M3**)

*Allow  $3 \times \text{M2}$ .*

1

Mass I<sub>2</sub> =  $7.62 \times 10^{-2} \times 253.8 = 19.34\text{g}$  (**M4**)

*Allow **M3**  $\times$  253.8 or **M3**  $\times$  254*

1

Scaling  $19.34 / 0.832 = 23.2\text{g}$  (**M5**)

*Allow **M4** / 0.832*

*Lose this mark if the answer is not given to 3 significant figures.*

*Answer without working scores **M5** only.*

*Allow any chemically correct alternative method.*

*Calculations which combine several steps in one expression can score the marks for all of these individual steps.*

1

(c) Remove soluble impurities

*Allow 'remove excess sodium hydroxide / iodine'.*

*Allow 'remove excess sodium methanoate / sodium iodide'.*

*Allow 'remove excess reagents'.*

1

(d) Will not dissolve solid / solid is insoluble in water



Allow 'will not react with solid'.

1

[8]

### Q18.

- (a) Sn / HCl **OR** Fe / HCl not conc H<sub>2</sub>SO<sub>4</sub> nor any HNO<sub>3</sub>

Ignore subsequent use of NaOH

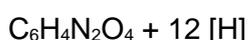
Ignore reference to Sn as a catalyst with the acid

Allow H<sub>2</sub> (Ni / Pt) but penalise wrong metal

But NOT NaBH<sub>4</sub> LiAlH<sub>4</sub> Na / C<sub>2</sub>H<sub>5</sub>OH

1

**Equation must use molecular formulae**



12[H] and 4H<sub>2</sub>O without correct molecular formula scores 1 out of 2

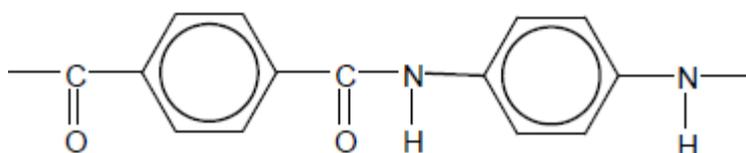
1



Allow .... + 6H<sub>2</sub> if H<sub>2</sub> / Ni used

Allow -CONH- or -COHN- or -C<sub>6</sub>H<sub>4</sub>-

1



Mark two halves separately: lose 1 each for

- error in diamine part
- error in diacid part
- error in peptide link
- missing trailing bonds at one or both ends
- either or both of H or OH on ends

Ignore n

2

- (b) H<sub>2</sub> (Ni / Pt) but penalise wrong metal  
NOT Sn / HCl, NaBH<sub>4</sub> etc.

1

CH<sub>2</sub>

1

In benzene 120°

1

In cyclohexane 109° 28' or 109½°

Allow 108° - 110°

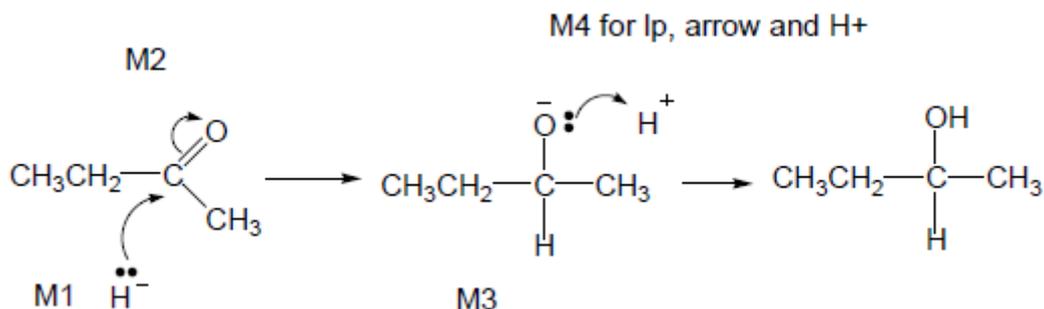


If only one angle stated without correct qualification, no mark awarded

1

(c) (i) Nucleophilic addition

1



- M2 not allowed independent of M1, but allow M1 for correct attack on C+
- + rather than  $\delta+$  on C=O loses M2
- M3 is for correct structure including minus sign but lone pair is part of M4
- Allow C<sub>2</sub>H<sub>5</sub>
- M1 and M4 include lp and curly arrow
- Allow M4 arrow to H in H<sub>2</sub>O (ignore further arrows)

4

(ii) M1 Planar C=O (bond / group)  
Not just planar molecule

1

M2 Attack (equally likely) from either side  
Not just planar bond without reference to carbonyl

1

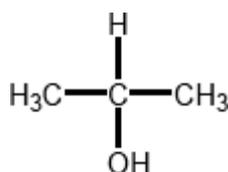
M3 (about product): Racemic mixture formed **OR** 50:50 mixture or each enantiomer equally likely

1

[17]

Q19.

L



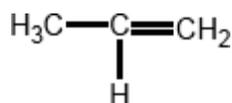
Allow (CH<sub>3</sub>)<sub>2</sub>CHOH or CH<sub>3</sub>CH(OH)CH<sub>3</sub>

Allow name propan-2-ol

Penalise contradiction of name and structure

1

M



Allow  $\text{CH}_3\text{CH}=\text{CH}_2$

*Allow name propene*

*ignore -1- but penalise other numbers*

*Penalise contradiction of name and structure*

1

Step 1  $\text{NaBH}_4$  or  $\text{LiAlH}_4$

$\text{Zn}/\text{HCl}$  or  $\text{Sn}/\text{HCl}$

or  $\text{H}_2/\text{Ni}$  or  $\text{H}_2/\text{Pt}$

*Ignore name if formula is correct*

*ignore solvent*

*ignore acid (for 2nd step) but penalise acidified  $\text{NaBH}_4$*

*Apply list principle for extra reagents and catalysts.*

M1

1

(nucleophilic) addition

Addition (not nucleophilic)

*Penalise electrophilic*

*Ignore reduction*

M2

1

Step 2 conc  $\text{H}_2\text{SO}_4$  or conc  $\text{H}_3\text{PO}_4$  or  $\text{Al}_2\text{O}_3$

*Apply list principle for extra reagents and catalysts.*

M3

1

elimination

*Independent from M3*

*penalise nucleophilic or electrophilic*

*ignore dehydration*

M4

1

Step 3  $\text{HBr}$

*Apply list principle for extra reagents and catalysts.*

M5

1

electrophilic addition

*Independent from M5*



M6

1

[8]

## Q20.

- (a) (i) Green  
*Ignore shades of green.* 1
- (ii) Excess acidified potassium dichromate(VI) 1
- Reflux (for some time) 1
- In the diagram credit should be given for
- a vertical condenser  
*Lose M3 and M4 for a distillation apparatus.* 1
  - an apparatus which would clearly work  
*Do not allow this mark for a flask drawn on its own.  
Penalise diagrams where the apparatus is sealed.* 1
- (iii) Distillation 1
- Immediately (the reagents are mixed) 1
- (b) Keep away from naked flames  
*Allow heat with water-bath or heating mantle.  
If a list is given ignore eye protection, otherwise lose this mark.* 1
- (c) (i) Tollens' or Fehling's reagents  
*Incorrect reagent(s) loses **both** marks.  
Accept mis-spellings if meaning is clear.* 1
- Silver mirror / red ppt. formed  
*Accept 'blue to red' but not 'red' alone.* 1
- (ii) Sodium carbonate (solution) / Group II metal  
*Allow indicator solutions with appropriate colours.  
Accept any named carbonate or hydrogen carbonate.* 1
- Effervescence / evolves a gas  
*Accept 'fizzes'.* 1



(d) Propanoic acid

*If this mark is lost allow one mark if there is reference to stronger intermolecular forces in the named compound.*

*Lose M1 and M3.*

1

Contains hydrogen bonding

1

Some comparison with other compounds explaining that the intermolecular forces are stronger in propanoic acid

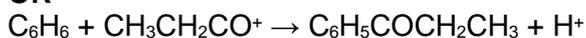
1

[15]

### Q21.



**OR**



*allow C<sub>2</sub>H<sub>5</sub>*

*penalise C<sub>6</sub>H<sub>5</sub>-CH<sub>3</sub>CH<sub>2</sub>CO*

*allow + on C or O in equation*

1

Phenylpropanone

**OR** ethylphenylketone **OR** phenylethylketone

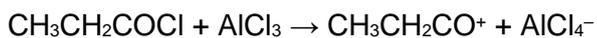
*Ignore 1 in formula, but penalise other numbers*

1

AlCl<sub>3</sub>

*can score in equation*

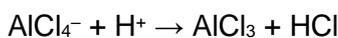
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*allow C<sub>2</sub>H<sub>5</sub>*

*allow + on C or O in equation*

1

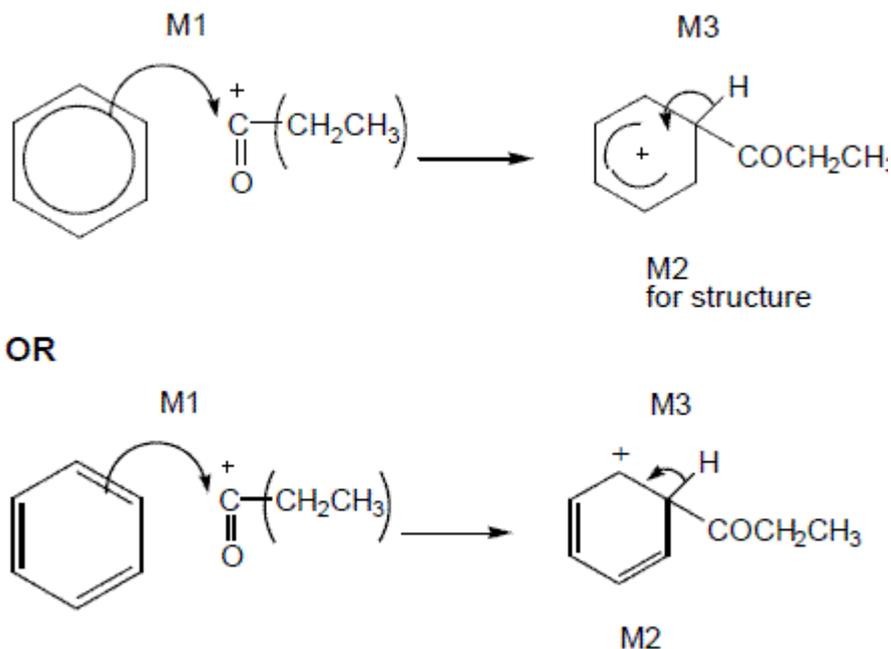


1

(ii) electrophilic substitution

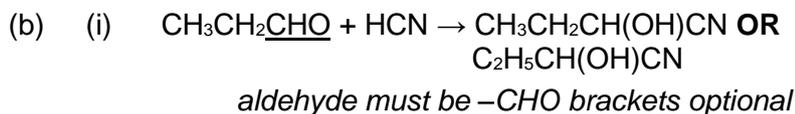
*can allow in (a)(i) if no contradiction*

1



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

3



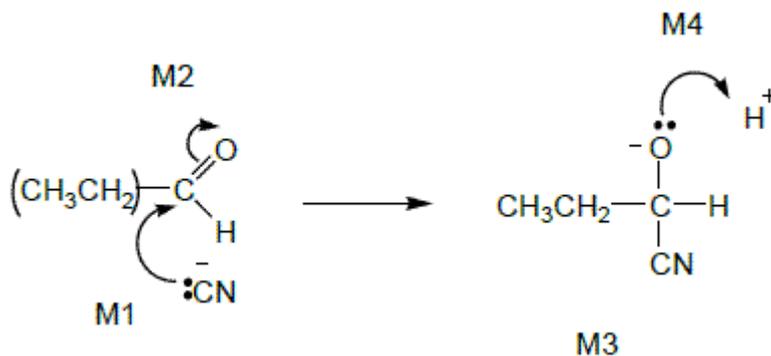
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2-hydroxybutanenitrile OR 2-hydroxybutanonitrile  
 no others

1

(ii) nucleophilic addition

1



M1 includes lp and arrow to Carbonyl C and minus charge (on either C or N)



Not allow M2 before M1, but allow M1 to C<sup>+</sup> after non-scoring carbonyl arrow  
 Ignore δ<sup>+</sup>, δ<sup>-</sup> on carbonyl group, but if wrong way round or full + charge on C lose M2  
 M3 for correct structure including minus sign. Allow C<sub>2</sub>H<sub>5</sub>  
 M4 for lp and curly arrow to H<sup>+</sup>

4

(iii) (propanone) slower **OR** propanal faster

1

inductive effects of alkyl groups

**OR**

C of C=O less δ<sup>+</sup> in propanone

**OR**

alkyl groups in ketone hinder attack

**OR**

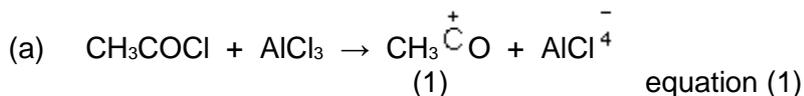
easier to attack at end of chain

*if wrong, no further marks*

1

[18]

### Q22.



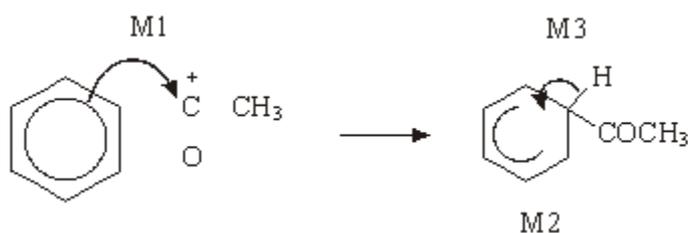
2

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<sub>3</sub> 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

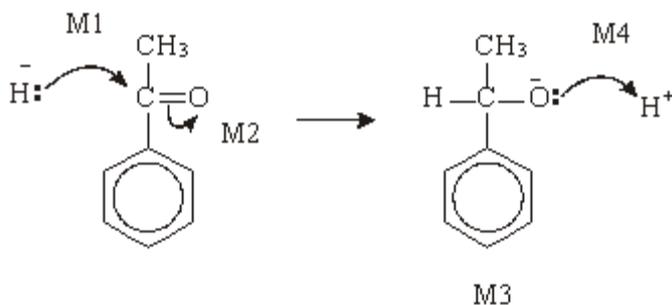
+ must be on C of  $\overset{+}{\text{R}}\text{CO}$

3



- (b) Nucleophilic addition  
*NOT reduction*

1



*M2 not allowed independent, but can allow M1 for attack of H⁻ on C=O formed*

4

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

1

- (c) dehydration or elimination

1

(conc)  $\text{H}_2\text{SO}_4$  or (conc)  $\text{H}_3\text{PO}_4$

*allow dilute and  $\text{Al}_2\text{O}_3$*

*Do not allow iron oxides*

1

[14]