

As part of CIE’s continual commitment to maintaining best practice in assessment, CIE has begun to use different variants of some question papers for our most popular assessments with extremely large and widespread candidature, The question papers are closely related and the relationships between them have been thoroughly established using our assessment expertise. All versions of the paper give assessment of equal standard.

The content assessed by the examination papers and the type of questions are unchanged.

This change means that for this component there are now two variant Question Papers, Mark Schemes and Principal Examiner’s Reports where previously there was only one. For any individual country, it is intended that only one variant is used. This document contains both variants which will give all Centres access to even more past examination material than is usually the case.

The diagram shows the relationship between the Question Papers, Mark Schemes and Principal Examiner’s Reports.

| <b>Question Paper</b>         | <b>Mark Scheme</b>         | <b>Principal Examiner’s Report</b>         |
|-------------------------------|----------------------------|--|
| Introduction                  | Introduction               | Introduction                               |
| First variant Question Paper  | First variant Mark Scheme  | First variant Principal Examiner’s Report  |
| Second variant Question Paper | Second variant Mark Scheme | Second variant Principal Examiner’s Report |

**Who can I contact for further information on these changes?**

Please direct any questions about this to CIE’s Customer Services team at: [international@cie.org.uk](mailto:international@cie.org.uk)

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

**MARK SCHEME for the May/June 2009 question paper  
for the guidance of teachers**

**9701 CHEMISTRY**

**9701/21**

Paper 2 (AS Structured Questions), maximum raw mark 60

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes must be read in conjunction with the question papers and the report on the examination.

- CIE will not enter into discussions or correspondence in connection with these mark schemes.

CIE is publishing the mark schemes for the May/June 2009 question papers for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level syllabuses and some Ordinary Level syllabuses.

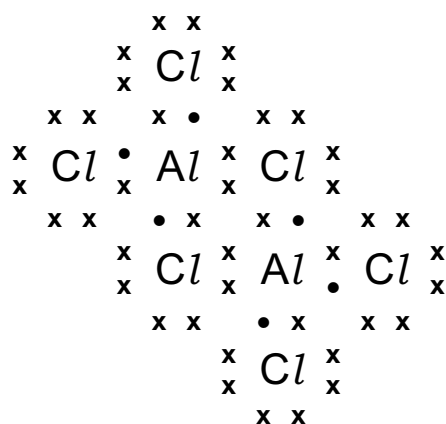


| Page 2 | Mark Scheme: Teachers' version | Syllabus | Paper |
|--------|--------------------------------|----------|-------|
|        | GCE A/AS LEVEL – May/June 2009 | 9701     | 21    |

- 1 (a) Al  $1s^2 2s^2 2p^6 3s^2 3p^1$  (1)
- Ti  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$  or  
 $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$  penalise any error (1) [2]

- (b) (i) pass chlorine gas (1)  
 over heated aluminium (1)
- (ii) aluminium glows (1)  
 white/yellow solid formed (1)  
 chlorine colour disappears/fades (1) (any 2)

(iii)



correct numbers of electrons, i.e.

3 • per Al atom and 7x per Cl atom

i.e. 6 • and 42 x in total (1)

dative bond Cl to Al clearly shown by  $x_x$  (1) [6]

- (c) chlorine is a strong/powerful oxidising agent (1) [1]

| Page 3 | Mark Scheme: Teachers' version | Syllabus | Paper |
|--------|--------------------------------|----------|-------|
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- (d) (i)  $n(\text{Ti}) = \frac{0.72}{47.9} = 0.015$  (1)
- (ii)  $n(\text{Cl}) = \frac{(2.85 - 0.72)}{35.5} = 0.06$  (1)
- (iii)  $0.015 : 0.06 = 1:4$   
 empirical formula of **A** is  $\text{TiCl}_4$   
 Allow ecf on answers to (i) and/or (ii). (1)
- (iv)  $\text{Ti} + 2\text{Cl}_2 \rightarrow \text{TiCl}_4$  (1)  
 Allow ecf on answers to (iii). [4]
- (e) covalent/not ionic (1)  
 simple molecular **or**  
 mention of weak intermolecular forces **or**  
 weak van der Waals's forces between molecules (1) [2]

[Total: 14 max]

- 2 (a) (i)  $\text{Mg}^+(\text{g}) \rightarrow \text{Mg}^{2+}(\text{g}) + \text{e}^-$  eqn. (1)  
 state symbols (1)
- (ii)  $736 + 1450 = +2186 \text{ kJ mol}^{-1}$  (1) [3]
- (b) (i) dissolves (1)  
 6 – 7 (1)
- (ii) does not dissolve/slightly soluble (1)  
 8 – 11 (1) [4]
- (c) (i)  $\text{Mg}_3\text{N}_2 + 6\text{H}_2\text{O} \rightarrow 3\text{Mg}(\text{OH})_2 + 2\text{NH}_3$  (1)
- (ii)  $\text{Mg}_3\text{N}_2$  N is  $-3$  (1)  
 $\text{NH}_3$  N is  $-3$  (1)
- No **because**  
 there is no change in the oxidation no. of N (1)  
 e.c.f on (c)(i) and values of oxidation numbers [4]

[Total: 11]

|        |                                |          |       |
|--------|--------------------------------|----------|-------|
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3 (a)  $2\text{CH}_3\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 4\text{H}_2\text{O}$  (1) [1]

(b)  $\text{SO}_2$  (1)

$\text{NO}_x / \text{NO}_2 / \text{NO}$  – **not**  $\text{N}_2\text{O}$  (1)

Pb compounds – **not** Pb (1) (any 2)

If more than two answers are given any wrong ones will be penalised. [2]

(c) low temperature (1)  
because forward reaction is exothermic (1)

high pressure (1)  
because forward reaction goes to fewer molecules (1)  
**or** shows a reduction in volume

increase  $[\text{CO}]$  **or**  $[\text{H}_2]$  (1)  
**or** remove  $\text{CH}_3\text{OH}$

correct explanation in terms of the effect of the change on the position of equilibrium or on the rate of reaction (1)  
(any two pairs) [4]

(d) (i) removes  $\text{CO}_2$  (1)  
which causes greenhouse effect/global warming (1)

(ii)

|               |                      |   |                      |                      |                      |   |                      |     |
|---------------|----------------------|---|----------------------|----------------------|----------------------|---|----------------------|-----|
|               | $\text{CO}_2$        | + | $\text{H}_2$         | $\rightleftharpoons$ | $\text{CO}$          | + | $\text{H}_2\text{O}$ |     |
| initial moles | 0.50                 |   | 0.50                 |                      | 0.20                 |   | 0.20                 |     |
| equil. moles  | $(0.50-x)$           |   | $(0.50-x)$           |                      | $(0.20+x)$           |   | $(0.20+x)$           | (1) |
| equil. concn. | $\frac{(0.50-x)}{1}$ |   | $\frac{(0.50-x)}{1}$ |                      | $\frac{(0.20+x)}{1}$ |   | $\frac{(0.20+x)}{1}$ |     |

$$K_c = \frac{[\text{CO}][\text{H}_2\text{O}]}{[\text{CO}_2][\text{H}_2]} \quad (1)$$

$$K_c = \frac{(0.20+x)^2}{(0.50-x)^2} = 1.44 \quad (1)$$

gives  $x = 0.18$  (1)

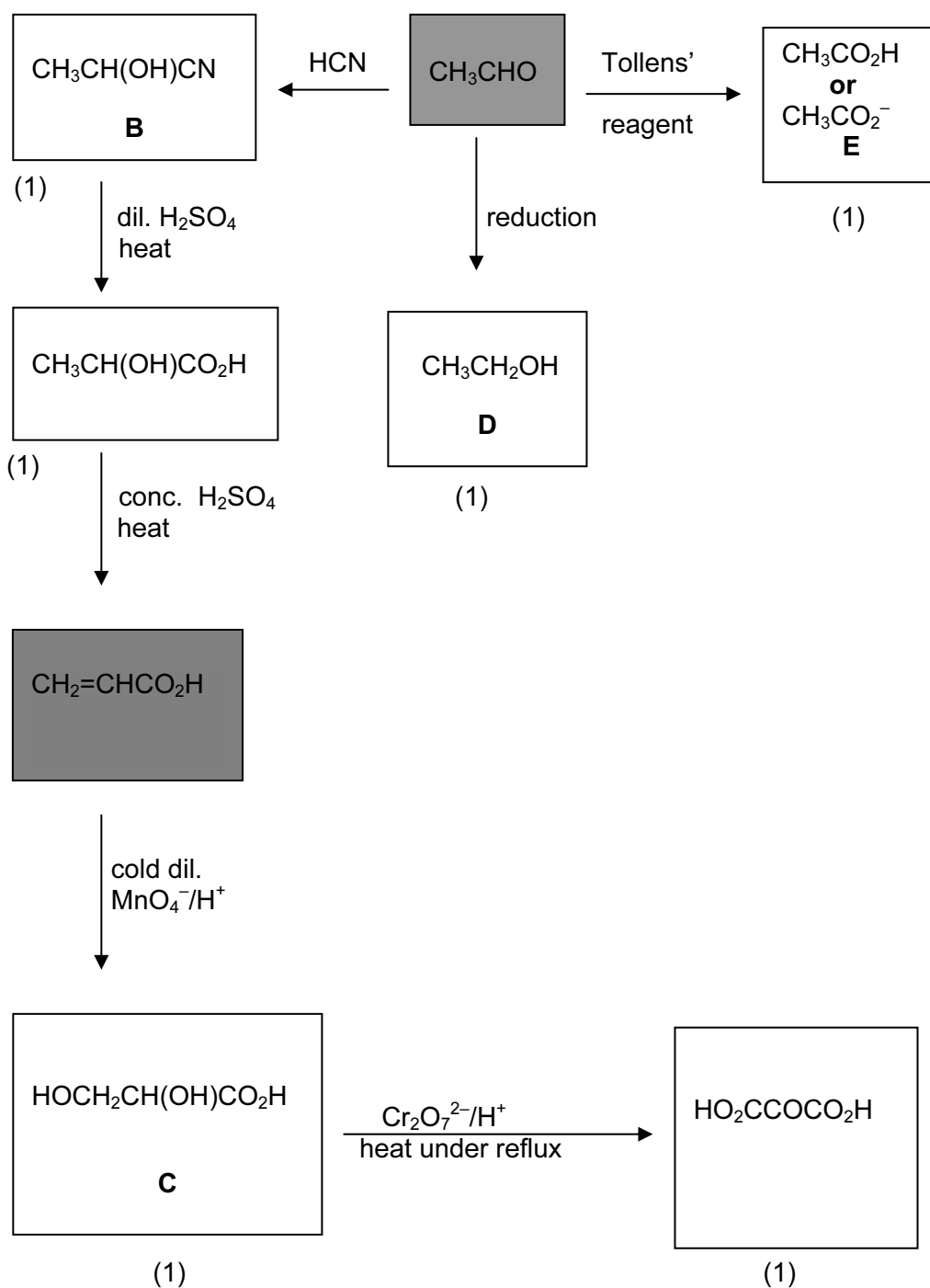
at equilibrium,  
 $n(\text{CO}_2) = n(\text{H}_2) = 0.32$  **and**  
 $n(\text{CO}) = n(\text{H}_2\text{O}) = 0.38$  (1)

Allow ecf on wrong values of x that are less than 0.5. [7]

[Total: 13 max]

|        |                                |          |       |
|--------|--------------------------------|----------|-------|
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4 (a)



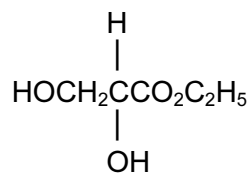
one mark for each correct structure

[6]

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(b) C + D

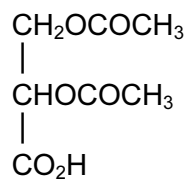
HOCH<sub>2</sub>CH(OH)CO<sub>2</sub>C<sub>2</sub>H<sub>5</sub> as minimum or



(1)

Allow e.c.f on candidate's C and/or D.

C + E



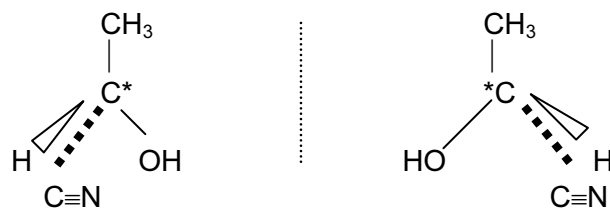
Allow either monoester.

(1)

[2]

Allow e.c.f on candidate's C and/or E.

(c)



correct chiral carbon atom indicated

(1)

**one** structure drawn fully displayed with C≡N

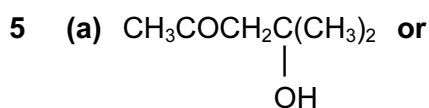
(1)

mirror object/mirror image pair correctly drawn in 3D

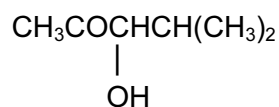
(1)

[3]

[Total: 11]



(by addition of one molecule of (CH<sub>3</sub>)<sub>2</sub>CO across the >C=O bond of another)



(by working backwards from G and adding one molecule of H<sub>2</sub>O across the C=C bond)

(1)

[1]

|        |                                |          |       |
|--------|--------------------------------|----------|-------|
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(b)

| functional group in G | reagent used in test                                      | what would be seen                        |
|-----------------------|---|---|
| alkene                | Br <sub>2</sub><br>or KMnO <sub>4</sub> (aq)              | decolourised                              |
| .....                 | .....   | .....                                     |
| or<br>carbonyl        | or<br>2,4-dinitro-<br>phenylhydrazine/<br>Brady's reagent | or<br>yellow/orange/red<br>colour or ppt. |

(1)

(1)

(1)

[3]

(c) (i) dehydration/elimination (1)

 (ii) Al<sub>2</sub>O<sub>3</sub> / P<sub>4</sub>O<sub>10</sub> / conc. H<sub>2</sub>SO<sub>4</sub>/ conc.H<sub>3</sub>PO<sub>4</sub> (1) [2]

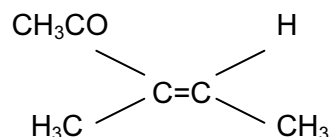
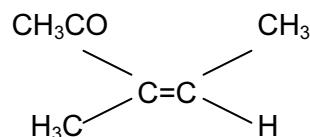
 (d) NaBH<sub>4</sub> or LiAlH<sub>4</sub> (1)

in water or methanol/ethanol or mixture of alcohol and water or in dry ether (1) [2]

not ether

Solvent mark is only awarded if reagent is correct.

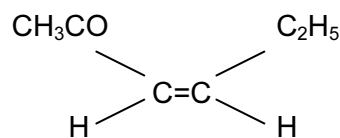
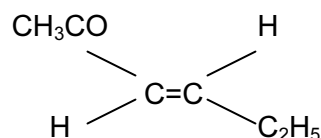
(e)


*cis\**

*trans\*\**

\* allow this to be called Z

\*\* allow this to be called E

or


*cis\**

*trans\*\**

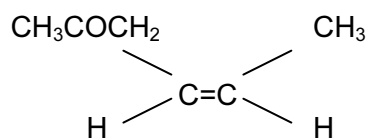
\* allow this to be called Z

\*\* allow this to be called E

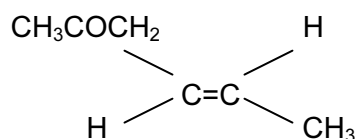


|        |                                |          |       |
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or



*cis* or *Z*



*trans* or *E*

two structures

(1)

correct *cis* and *trans*

(1)

explanation

(1)

[3]

For *cis* and *trans* answers, the explanation should be in terms of the methyl groups (first pair of isomers) or hydrogen atoms (second and third pairs of isomers) being on the same or opposite sides relative to the C=C bond.

For *E/Z* answers, the explanation will need to involve the relative sizes of the CH<sub>3</sub>C- group and the CH<sub>3</sub>- group. This really only affects the first pair of isomers.

[Total: 11]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

**MARK SCHEME for the May/June 2009 question paper  
for the guidance of teachers**

**9701 CHEMISTRY**

**9701/22**

Paper 22 (AS Structured Questions), maximum raw mark 60

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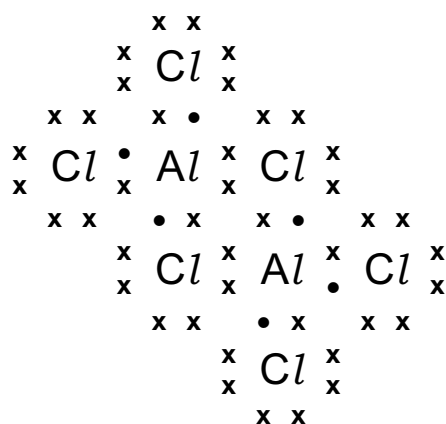


| Page 2 | Mark Scheme: Teachers' version | Syllabus | Paper |
|--------|--------------------------------|----------|-------|
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- 1 (a) Al  $1s^2 2s^2 2p^6 3s^2 3p^1$  (1)
- Ti  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$  or  
 $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$  penalise any error (1) [2]

- (b) (i) pass chlorine gas (1)  
 over heated aluminium (1)
- (ii) aluminium glows (1)  
 white/yellow solid formed (1)  
 chlorine colour disappears/fades (1) (any 2)

(iii)



correct numbers of electrons, i.e.

3 • per Al atom and 7x per Cl atom

i.e. 6 • and 42 x in total (1)

dative bond Cl to Al clearly shown by  $x_x$  (1) [6]

- (c) chlorine is a strong/powerful oxidising agent (1) [1]

| Page 3 | Mark Scheme: Teachers' version | Syllabus | Paper |
|--------|--------------------------------|----------|-------|
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- (d) (i)  $n(\text{Ti}) = \frac{0.72}{47.9} = 0.015$  (1)
- (ii)  $n(\text{Cl}) = \frac{(2.85 - 0.72)}{35.5} = 0.06$  (1)
- (iii)  $0.015 : 0.06 = 1:4$   
 empirical formula of **A** is  $\text{TiCl}_4$   
 Allow ecf on answers to (i) and/or (ii). (1)
- (iv)  $\text{Ti} + 2\text{Cl}_2 \rightarrow \text{TiCl}_4$  (1)  
 Allow ecf on answers to (iii). [4]

- (e) covalent/not ionic (1)
- simple molecular **or**  
 mention of weak intermolecular forces **or**  
 weak van der Waals's forces between molecules (1) [2]

[Total: 14 max]

- 2 (a) (i)  $\text{Ca}^+(\text{g}) \rightarrow \text{Ca}^{2+}(\text{g}) + \text{e}^-$  equation (1)  
 state symbols (1)
- (ii)  $590 + 1150 = +1740 \text{ kJ mol}^{-1}$  (1) [3]
- (b) (i) dissolves/vigorous reaction/  
 white or steamy fumes of  $\text{HCl}$  (1)  
 0 – 4 (1)
- (ii) dissolves/vigorous reaction (1)  
 0 – 4 (1) [4]
- (c) (i)  $\text{P}_4\text{S}_{10} + 16\text{H}_2\text{O} \rightarrow 4\text{H}_3\text{PO}_4 + 10\text{H}_2\text{S}$  (1)
- (ii)  $\text{P}_4\text{S}_{10}$  P is +5 (1)  
 $\text{H}_3\text{PO}_4$  P is +5 (1)
- No **because**  
 there is no change in the oxidation no. of P (1)  
 ecf on answer to (c)(i)  
 and on calculated oxidation numbers [4]

[Total: 11]

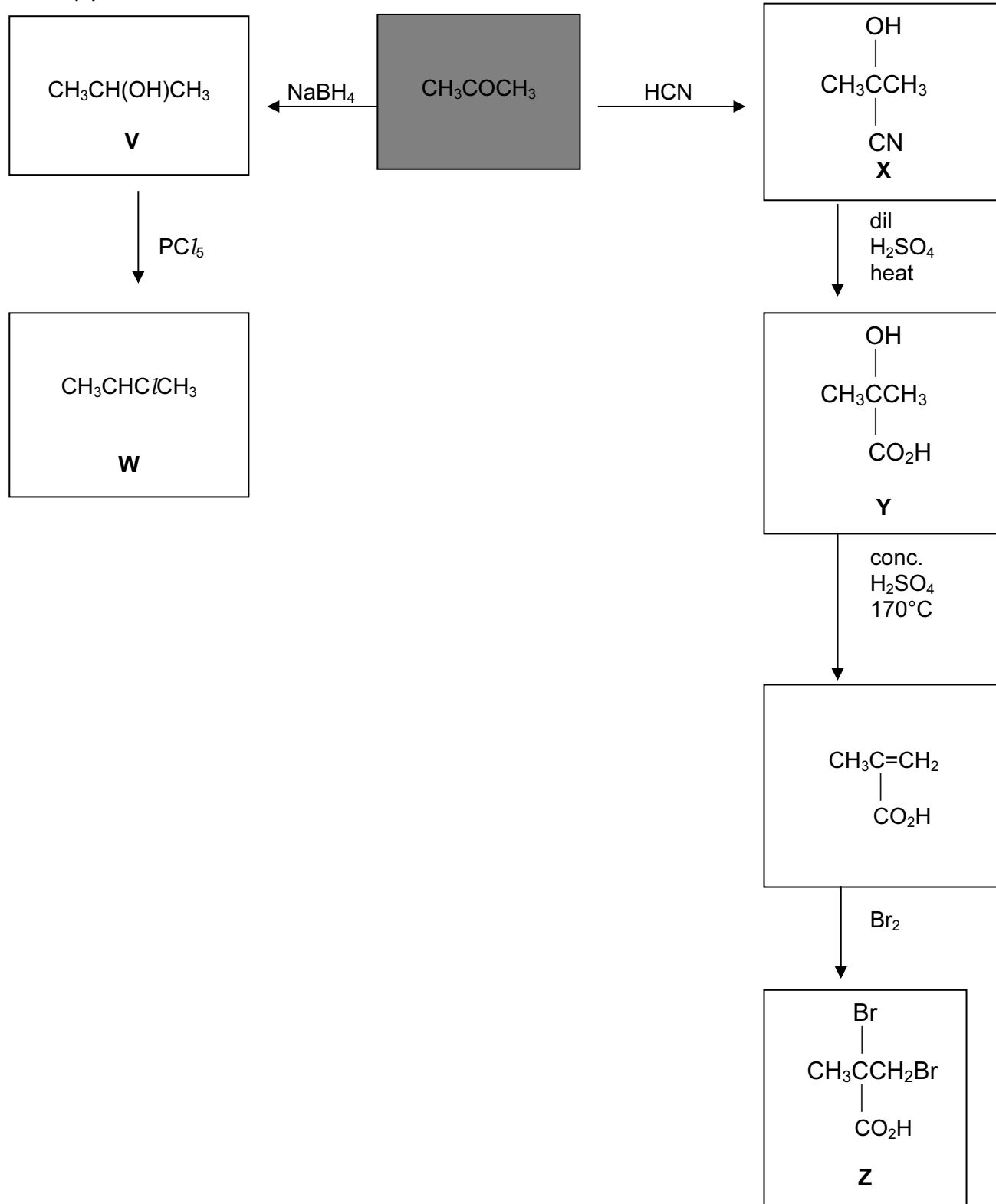
|        |                                |          |       |
|--------|--------------------------------|----------|-------|
| Page 4 | Mark Scheme: Teachers' version | Syllabus | Paper |
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- 3 (a)  $2\text{CH}_3\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 4\text{H}_2\text{O}$  (1) [1]
- (b)  $\text{SO}_2$  (1)
- $\text{NO}_x / \text{NO}_2 / \text{NO}$  – **not**  $\text{N}_2\text{O}$  (1)
- Pb compounds – **not** Pb (1) (any 2)
- if more than two answers are given any wrong ones will be penalised [2]
- (c) low temperature (1)  
because forward reaction is exothermic (1)
- high pressure (1)  
because forward reaction goes to fewer molecules (1)  
**or** shows a reduction in volume
- increase  $[\text{CO}]$  **or**  $[\text{H}_2]$  (1)  
**or** remove  $\text{CH}_3\text{OH}$  (1)  
correct explanation in terms of the effect of the change  
on the position of equilibrium or on the rate of reaction (1)
- (any two pairs) [4]
- (d) (i) removes  $\text{CO}_2$  (1)  
which causes greenhouse effect/global warming (1)
- (ii)
- |               |                      |   |                      |                      |                      |   |                      |     |
|---------------|----------------------|---|----------------------|----------------------|----------------------|---|----------------------|-----|
|               | $\text{CO}_2$        | + | $\text{H}_2$         | $\rightleftharpoons$ | $\text{CO}$          | + | $\text{H}_2\text{O}$ |     |
| initial moles | 0.50                 |   | 0.50                 |                      | 0.20                 |   | 0.20                 |     |
| equil. moles  | $(0.50-x)$           |   | $(0.50-x)$           |                      | $(0.20+x)$           |   | $(0.20+x)$           | (1) |
| equil. concn. | $\frac{(0.50-x)}{1}$ |   | $\frac{(0.50-x)}{1}$ |                      | $\frac{(0.20+x)}{1}$ |   | $\frac{(0.20+x)}{1}$ |     |
- $K_c = \frac{[\text{CO}][\text{H}_2\text{O}]}{[\text{CO}_2][\text{H}_2]}$  (1)
- $K_c = \frac{(0.20+x)^2}{(0.50-x)^2} = 1.44$  (1)
- gives  $x = 0.18$  (1)
- at equilibrium,  
 $n(\text{CO}_2) = n(\text{H}_2) = 0.32$  **and**  
 $n(\text{CO}) = n(\text{H}_2\text{O}) = 0.38$  (1)
- Allow ecf on wrong values of x that are less than 0.5. [7]

[Total: 13 max]

| Page 5 | Mark Scheme: Teachers' version | Syllabus | Paper |
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4 (a)



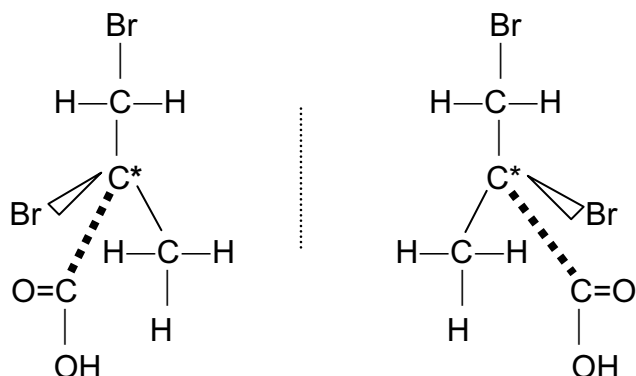
(each correct structure gets 1 mark)

[6]

| Page 6 | Mark Scheme: Teachers' version | Syllabus | Paper |
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- (b) (i) **Z**  
 allow ecf on candidate's **Z**  
 or other **chiral** compound (1)

(ii)



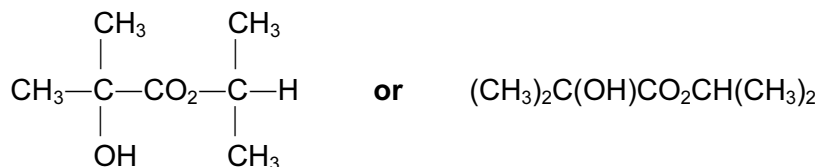
chiral centre clearly shown by \* (1)

**one** structure drawn fully displayed

especially  $-\text{CO}_2\text{H}$  group (1)

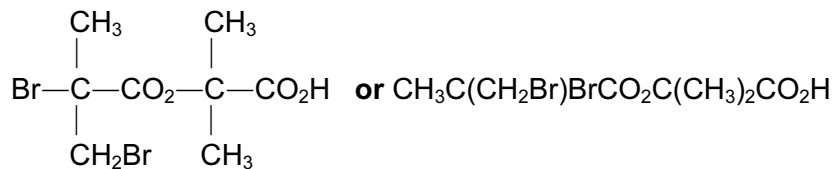
mirror object/mirror image pair correctly drawn in 3D (1) [4]

(c) (i) **Y + V**



allow ecf on **candidate's Y** and/or **V** (1)

(ii) **Y + Z**



allow ecf on **candidate's Y** and/or **Z** (1) [2]

[Total: 11 max]

|        |                                |          |       |
|--------|--------------------------------|----------|-------|
| Page 7 | Mark Scheme: Teachers' version | Syllabus | Paper |
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- 5 (a)  $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CHO}$  (by addition of one molecule of  $\text{CH}_3\text{CHO}$  across the  $>\text{C}=\text{O}$  bond of another)
- or
- $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CHO}$  (by working backwards from **U** and adding one molecule of  $\text{H}_2\text{O}$  across the  $\text{C}=\text{C}$  bond 'the other way') (1) [1]

(b)

| functional group in <b>U</b> | reagent used in test                                      | what would be seen                        |
|------------------------------|---|---|
| alkene                       | $\text{Br}_2$<br>or $\text{KMnO}_4(\text{aq})$            | decolourised                              |
| .....                        | .....   | .....                                     |
| or<br>carbonyl<br>not ketone | or<br>2,4-dinitro-<br>phenylhydrazine/<br>Brady's reagent | or<br>yellow/orange/red<br>colour or ppt. |
| .....                        | .....   | .....                                     |
| or<br>aldehyde               | or<br>Tollens' reagent                                    | or<br>silver ppt./mirror<br>black colour  |
|                              | or<br>Fehling's solution                                  | or<br>brick red ppt.                      |

(1)

(1)

(1)

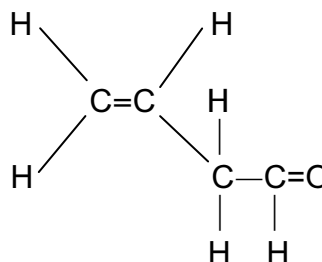
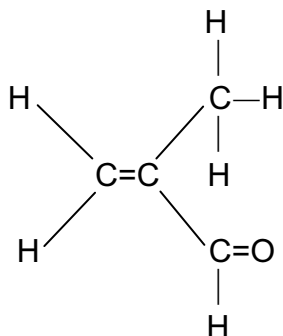
[3]

- (c) (i) dehydration/elimination (1)
- (ii)  $\text{Al}_2\text{O}_3/\text{P}_4\text{O}_{10}/\text{conc. H}_2\text{SO}_4/\text{conc. H}_3\text{PO}_4$  (1) [2]
- (d)  $\text{NaBH}_4$  or  $\text{LiAlH}_4$  (1)
- in water or methanol or ethanol or mixture of water and alcohol or in **dry** ether (1)
- not** ether
- Solvent mark is only to be awarded if reagent is correct. [2]

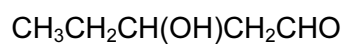


| Page 8 | Mark Scheme: Teachers' version | Syllabus | Paper |
|--------|--------------------------------|----------|-------|
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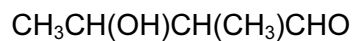
5 (e)



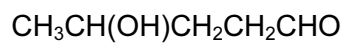
two structures (1) + (1) [2]



or



allow



(1) [1]

**[Total: 11]**