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.

Question Paper	**Mark Scheme**	**Principal Examiner's Report**
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

First variant Mark Scheme

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.

UNIVERSITY of CAMBRIDGE
International Examinations

1 **(a)** A*l* $1s^2\ 2s^2 2p^6\ 3s^2 3p^1$ (1)

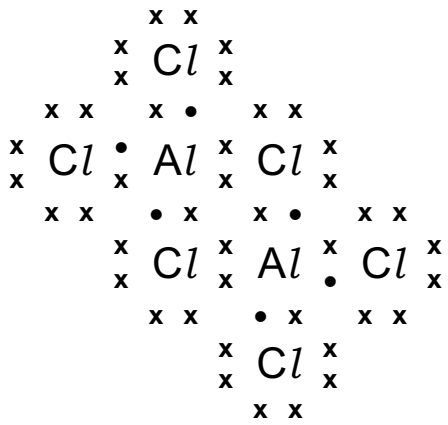
Ti $1s^2\ 2s^2 2p^6\ 3s^2\ 3p^6\ 3d^2\ 4s^2$ **or**

$1s^2\ 2s^2 2p^6\ 3s^2\ 3p^6\ 4s^2 3d^2$ 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 A*l* atom **and 7x** per C*l* atom

i.e. 6 • and 42 **x** in total (1)

dative bond C*l* to A*l* clearly shown by $^{x}_{x}$ (1) [6]

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

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(d) **(i)** n(Ti) = $\frac{0.72}{47.9}$ = 0.015 (1)

(ii) n(Cl) = $\frac{(2.85 - 0.72)}{35.5}$ = 0.06 (1)

(iii) 0.015 : 0.06 = 1:4
empirical formula of **A** is TiCl_4
Allow ecf on answers to **(i)** and/or **(ii)**. (1)

(iv) Ti + 2Cl_2 → 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)** $Mg^+(g) \rightarrow Mg^{2+}(g) + e^-$ eqn. (1)
state symbols (1)

(ii) 736 + 1450 = +2186 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)** $Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3$ (1)

(ii) Mg_3N_2 N is –3 (1)
NH_3 N is –3 (1)

No **because**
there is no change in the oxidation no. of N (1) [4]
e.c.f on **(c)(i)** and values of oxidation numbers

[Total: 11]

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3 **(a)** $2CH_3OH + 3O_2 \rightarrow 2CO_2 + 4H_2O$ (1) [1]

(b) SO_2 (1)

NO_x / NO_2 / NO – **not** N_2O (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 [CO] **or** $[H_2]$
or remove CH_3OH (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 CO_2 (1)
which causes greenhouse effect/global warming (1)

(ii)

	CO_2	+ H_2	$\rightleftharpoons$ CO	+ H_2O
initial moles	0.50	0.50	0.20	0.20
equil. moles	(0.50-x)	(0.50-x)	(0.20+x)	(0.20+x)
equil. concn.	$\frac{(0.50-x)}{1}$	$\frac{(0.50-x)}{1}$	$\frac{(0.20+x)}{1}$	$\frac{(0.20+x)}{1}$

(1)

$K_c = \frac{[CO][H_2O]}{[CO_2][H_2]}$ (1)

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

gives x = 0.18 (1)

at equilibrium,
$n(CO_2) = n(H_2) = 0.32$ **and**
$n(CO) = n(H_2O) = 0.38$ (1)

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

[Total: 13 max]

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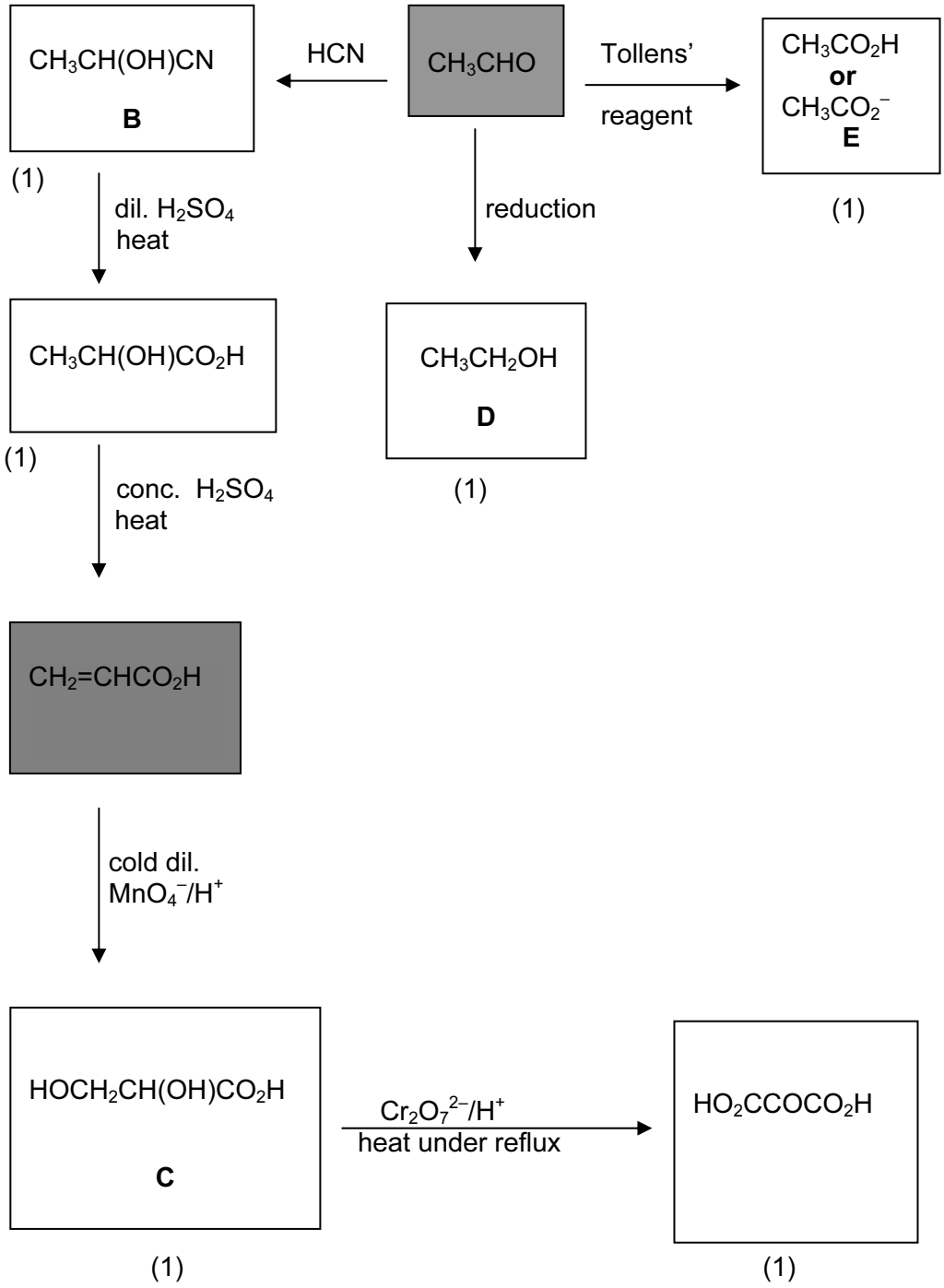
4 (a)



one mark for each correct structure [6]

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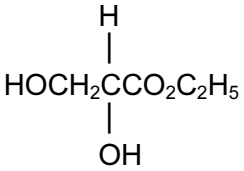
(b) C + D

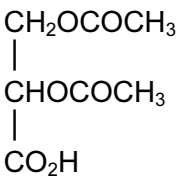
$HOCH_2CH(OH)CO_2C_2H_5$ as minimum or



(1)

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

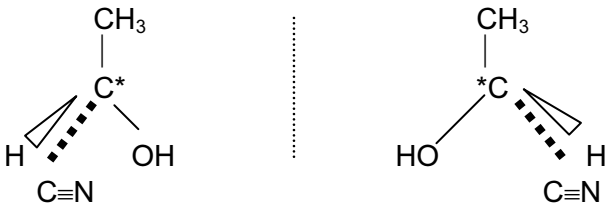
C + E



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]

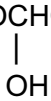
[Total: 11]

5 (a) $CH_3COCH_2C(CH_3)_2$ **or**



(by addition of one molecule of $(CH_3)_2CO$ across the >C=O bond of another)

$CH_3COCHCH(CH_3)_2$



(by working backwards from **G** and adding one molecule of H_2O 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 ..... **or** carbonyl	Br_2 **or** $KMnO_4$(aq) ..... **or** 2,4-dinitro-phenylhydrazine/ Brady's reagent	decolourised ..... **or** yellow/orange/red colour or ppt.
(1)	(1)	(1)

[3]

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

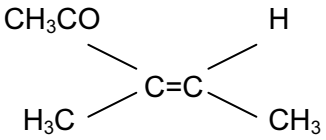
(ii) Al_2O_3 / P_4O_{10} / conc. H_2SO_4/ conc.H_3PO_4 (1) [2]

(d) $NaBH_4$ **or** $LiAlH_4$ (1)

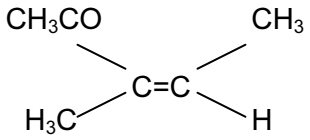
in water **or** methanol/ethanol **or** mixture of alcohol and water **or** in **dry** ether (1) [2]

not ether
Solvent mark is only awarded if reagent is correct.

(e)



*cis**

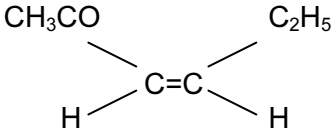


*trans***

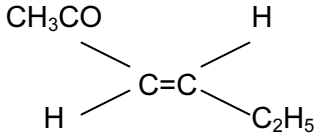
* allow this to be called Z

** 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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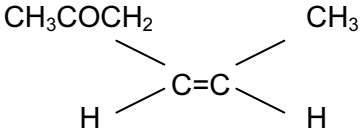
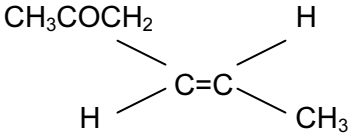
or



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_3C- group and the CH_3- group. This really only affects the first pair of isomers.

[Total: 11]

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Second variant Mark Scheme

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

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.

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Page 2	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2009	9701	22

1 **(a)** A*l* $1s^2\ 2s^2 2p^6\ 3s^2 3p^1$ (1)

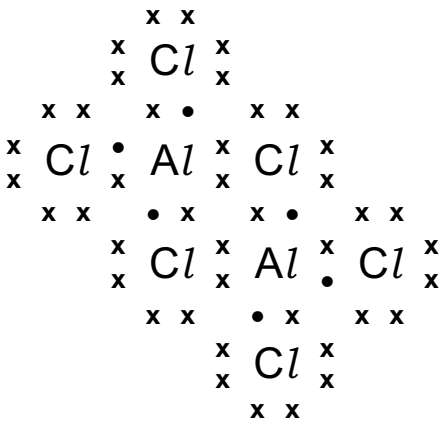
Ti $1s^2\ 2s^2 2p^6\ 3s^2\ 3p^6\ 3d^2\ 4s^2$ **or**

$1s^2\ 2s^2 2p^6\ 3s^2\ 3p^6\ 4s^2 3d^2$ 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 A*l* atom **and 7x** per C*l* atom

i.e. 6 • and 42 **x** in total (1)

dative bond C*l* to A*l* clearly shown by $^{x}_{x}$ (1) [6]

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

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(d) (i) $n(Ti) = \frac{0.72}{47.9} = 0.015$ (1)

(ii) $n(Cl) = \frac{(2.85 - 0.72)}{35.5} = 0.06$ (1)

(iii) 0.015 : 0.06 = 1:4
empirical formula of **A** is $TiCl_4$
Allow ecf on answers to **(i)** and/or **(ii)**. (1)

(iv) $Ti + 2Cl_2 \rightarrow TiCl_4$ (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) $Ca^+(g) \rightarrow Ca^{2+}(g) + e^-$ equation (1)
state symbols (1)

(ii) 590 + 1150 = +1740 kJ mol^{-1} (1) [3]

(b) (i) dissolves/vigorous reaction/
white or steamy fumes of HCl (1)
0 – 4 (1)

(ii) dissolves/vigorous reaction (1)
0 – 4 (1) [4]

(c) (i) $P_4S_{10} + 16H_2O \rightarrow 4H_3PO_4 + 10H_2S$ (1)

(ii) P_4S_{10} P is +5 (1)
H_3PO_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]

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3 **(a)** $2CH_3OH + 3O_2 \rightarrow 2CO_2 + 4H_2O$ (1) [1]

(b) SO_2 (1)

NO_x / NO_2 / NO – **not** N_2O (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 [CO] **or** $[H_2]$
or remove CH_3OH (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 CO_2 (1)
which causes greenhouse effect/global warming (1)

(ii)

	CO_2	+ H_2	$\rightleftharpoons$ CO	+ H_2O
initial moles	0.50	0.50	0.20	0.20
equil. moles	(0.50-x)	(0.50-x)	(0.20+x)	(0.20+x)
equil. concn.	$\frac{(0.50-x)}{1}$	$\frac{(0.50-x)}{1}$	$\frac{(0.20+x)}{1}$	$\frac{(0.20+x)}{1}$

(1)

$K_c = \frac{[CO][H_2O]}{[CO_2][H_2]}$ (1)

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

gives x = 0.18 (1)

at equilibrium,
$n(CO_2) = n(H_2) = 0.32$ **and**
$n(CO) = n(H_2O) = 0.38$ (1)

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

[Total: 13 max]

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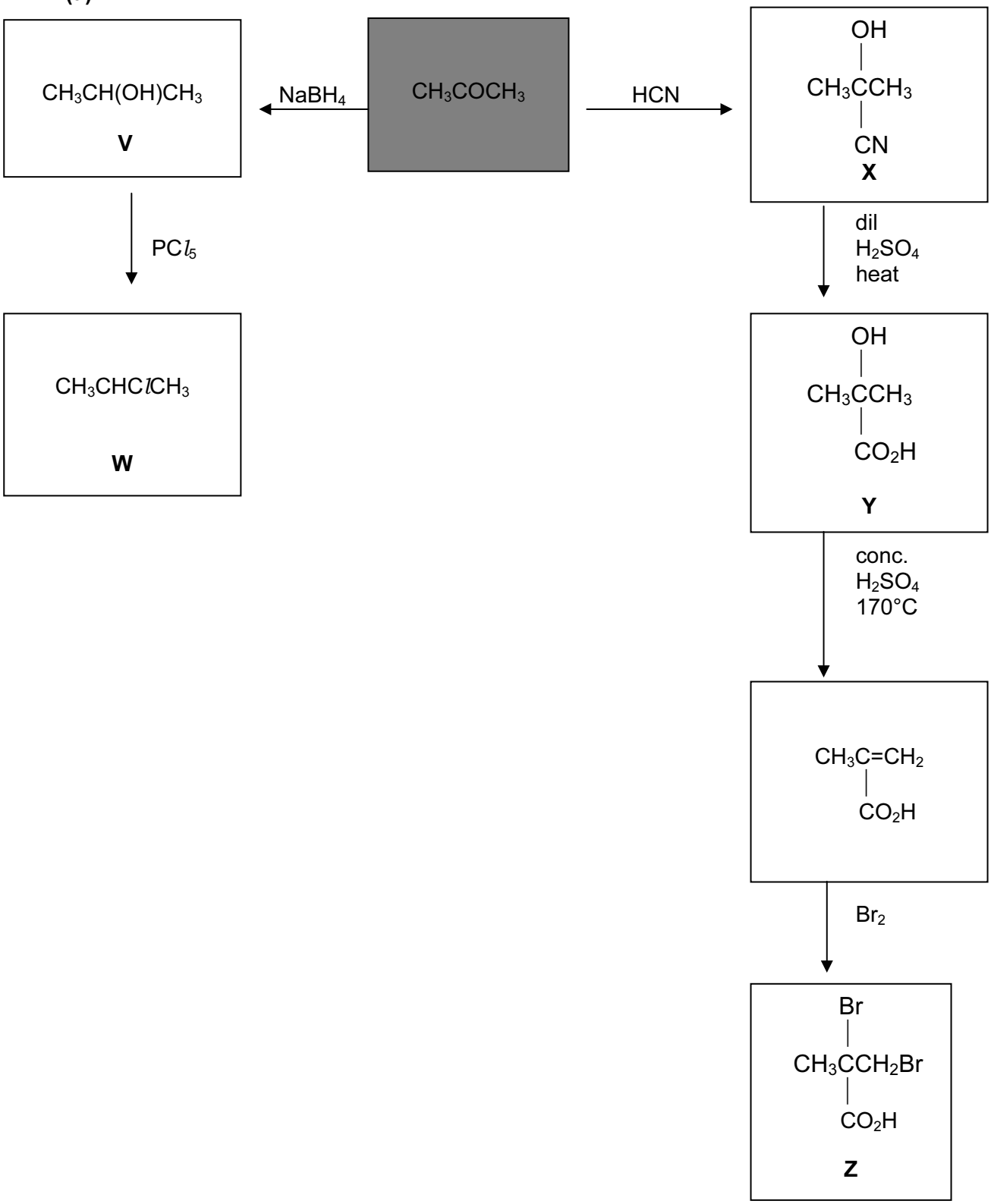
4 (a)



(each correct structure gets 1 mark) [6]

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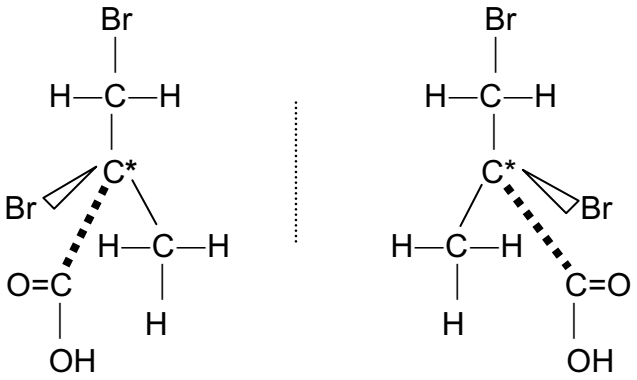
(b) (i) Z

allow ecf on candidate's **Z**
or other **chiral** compound (1)

(ii)



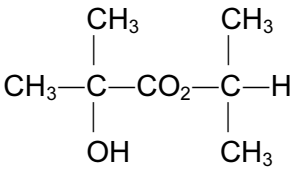
chiral centre clearly shown by * (1)

one structure drawn fully displayed

especially $–CO_2H$ group (1)

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

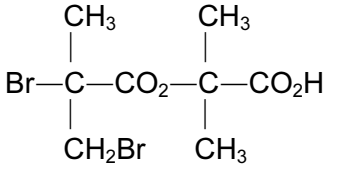
(c) (i) Y + V



or $(CH_3)_2C(OH)CO_2CH(CH_3)_2$

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

(ii) Y + Z



or $CH_3C(CH_2Br)BrCO_2C(CH_3)_2CO_2H$

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

[Total: 11 max]

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5 **(a)** $CH_3CH(OH)CH_2CHO$ (by addition of one molecule of CH_3CHO across the >C=O bond of another)

or

$CH_3CH_2CH(OH)CHO$ (by working backwards from **U** and adding one molecule of H_2O across the C=C bond 'the other way') (1) [1]

(b)

functional group in **U**	reagent used in test	what would be seen
alkene	Br_2 **or** $KMnO_4$(aq)	decolourised
.....	.....	.....
or carbonyl not ketone	**or** 2,4-dinitro-phenylhydrazine/ Brady's reagent	**or** yellow/orange/red colour or ppt.
.....	.....	.....
or aldehyde	**or** Tollens' reagent	**or** silver ppt./mirror black colour
	or	**or**
	Fehling's solution	brick red ppt.
(1)	(1)	(1) [3]

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

(ii) Al_2O_3/P_4O_{10}/conc. H_2SO_4/conc. H_3PO_4 (1) [2]

(d) $NaBH_4$ **or** $LiAlH_4$ (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]

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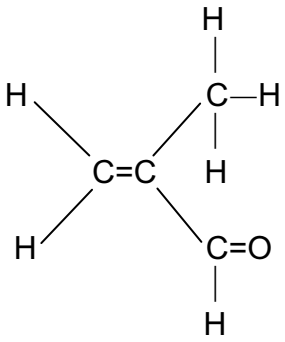
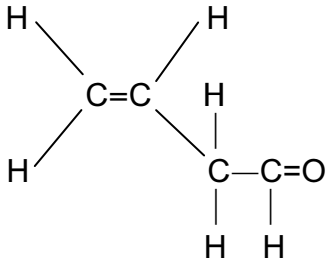
5 (e)





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

$CH_3CH_2CH(OH)CH_2CHO$

or

$CH_3CH(OH)CH(CH_3)CHO$

allow

$CH_3CH(OH)CH_2CH_2CHO$ (1) [1]

[Total: 11]

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