

**UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS**

**GCE Advanced Subsidiary Level and GCE Advanced Level**

**MARK SCHEME for the October/November 2011 question paper  
for the guidance of teachers**

**9701 CHEMISTRY**

**9701/22**

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.

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UNIVERSITY of CAMBRIDGE  
International Examinations

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- 1 (a) (i) mass of C =  $\frac{12 \times 0.352}{44} = 0.096\text{g}$  (1)
- $n(\text{C}) = \frac{0.096}{12} = 0.008$  (1)
- (ii) mass of H =  $\frac{2 \times 0.144}{18} = 0.016\text{g}$  (1)
- $n(\text{H}) = \frac{0.016}{1} = 0.016$  (1)
- (iii) mass of oxygen =  $0.240 - (0.096 + 0.016) = 0.128\text{g}$  (1)
- $n(\text{O}) = \frac{0.128}{16} = 0.008$  (1)
- allow ecf at any stage [6]
- (b) C : H : O = 0.008 : 0.016 : 0.008 = 1:2:1
- allow C : H : O =  $\frac{0.096}{12} : \frac{0.016}{1} : \frac{0.128}{16} = 1:2:1$
- gives  $\text{C}_2\text{H}_4\text{O}$  (1) [1]
- (c) (i)  $M_r = \frac{mRT}{pV} = \frac{0.148 \times 8.31 \times 333}{1.01 \times 10^5 \times 67.7 \times 10^{-6}}$  (1)
- = 59.89
- allow 59.9 or 60 (1)
- (ii)  $\text{C}_2\text{H}_4\text{O}_2$  (1) [3]
- (d)  $\text{CH}_3\text{CO}_2\text{H}$  (1)
- $\text{HCO}_2\text{CH}_3$  (1) [2]
- (e) the only products of the reaction are the two oxides  $\text{H}_2\text{O}$  and  $\text{CO}_2$  and copper (1) [1]

**[Total: 13]**

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2 (a)  $S(g) \rightarrow S^+(g) + e^-$   
correct equation (1)  
correct state symbols (1) [2]

(b) **from Na to Ar,**  
electrons are added to the same shell/have same shielding (1)  
electrons are subject to increasing nuclear charge/proton number (1)  
electrons are closer to the nucleus **or** atom gets smaller (1) [3]

(c) (i) **Mg and Al**  
in Mg outermost electron is in 3s **and**  
in Al outermost electron is in 3p (1)

3p electron is at higher energy **or**  
is further away from the nucleus **or**  
is more shielded from the nucleus (1)

(ii) **S and P**  
for S one 3p orbital has paired electrons **and**  
for P 3p sub-shell is singly filled (1)

paired electrons repel (1) [4]

(d) (i) and (ii)

element	Na	Mg	Al	Si	P	S
conductivity	high	high	—	moderate	low	low
melting point	low	high	—	high	low	low

(1) (1) (1) (1) (1)

one mark for each correct column [5]

(e) germanium/Ge (1) [1]

**[Total: 15]**

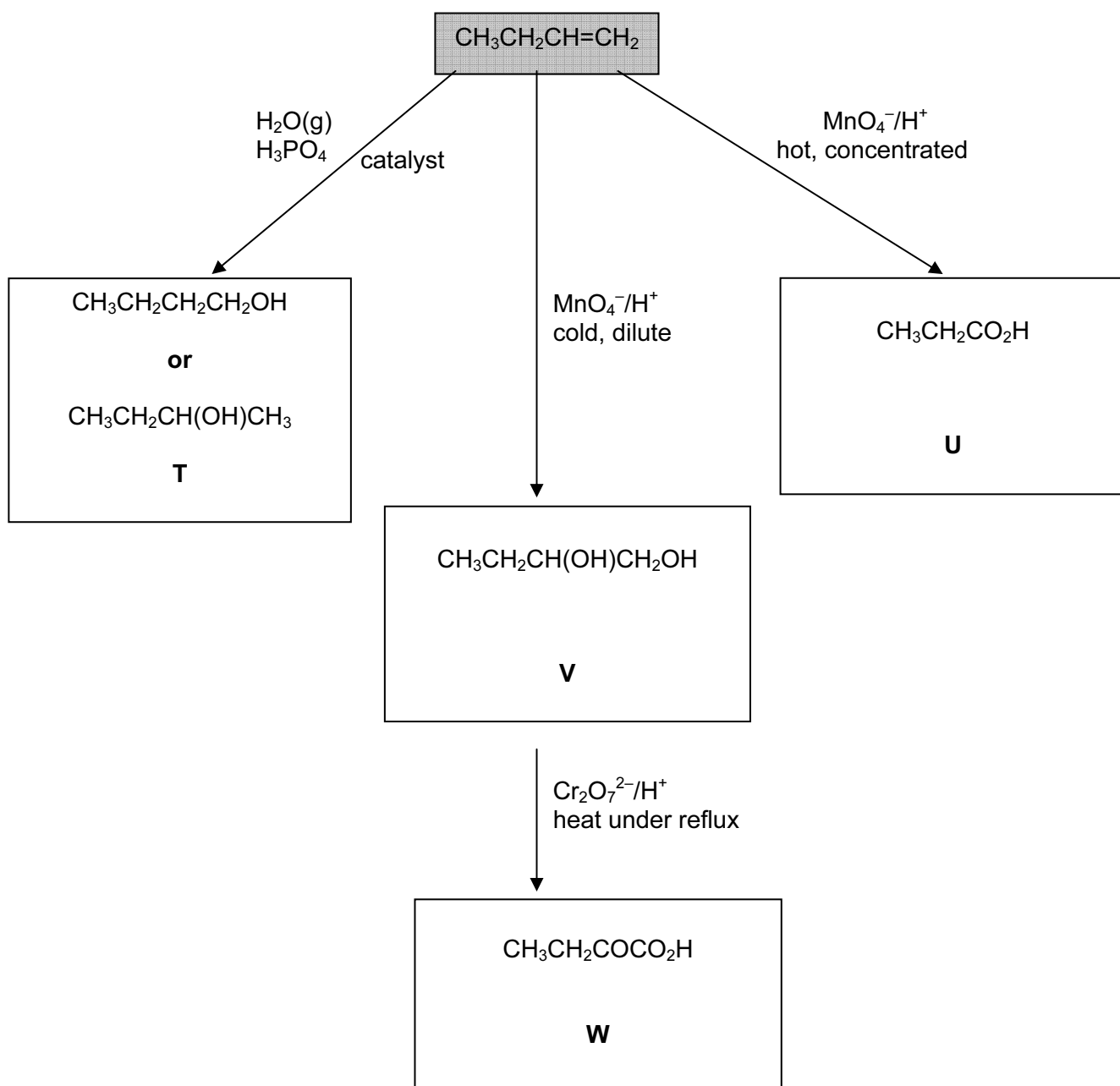
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- 3 (a) the overall enthalpy change/energy change/ $\Delta H$  for a reaction (1)
- is independent of the route taken **or**  
 is independent of the number of steps involved  
 provided the initial and final conditions are the same (1) [2]
- (b) (i)  $K_2CO_3 + 2HCl \rightarrow 2KCl + H_2O + CO_2$  (1)
- (ii) heat produced =  $m \times c \times \delta T = 30.0 \times 4.18 \times 5.2$   
 $= 652.08 \text{ J per } 0.0200 \text{ mol of } K_2CO_3$  (1)
- (iii)  $0.020 \text{ mol } K_2CO_3 \equiv 652.08 \text{ J}$   
 $1 \text{ mol } K_2CO_3 \equiv \frac{652.08 \times 1}{0.0200} = 32604 \text{ J}$   
 enthalpy change =  $-32.60 \text{ kJmol}^{-1}$  (1)
- (iv) to prevent the formation of  $KHCO_3$  **or**  
 to ensure complete neutralisation (1) [4]
- (c) (i)  $KHCO_3 + HCl \rightarrow KCl + H_2O + CO_2$  (1)
- (ii) heat absorbed =  $m \times c \times \delta T = 30.0 \times 4.18 \times 3.7$   
 $= 463.98 \text{ J per } 0.0200 \text{ mol of } KHCO_3$  (1)
- (iii)  $0.020 \text{ mol } KHCO_3 \equiv 463.98 \text{ J}$   
 $1 \text{ mol } KHCO_3 \equiv \frac{463.98 \times 1}{0.0200} = 23199 \text{ J}$   
 enthalpy change =  $+23.20 \text{ kJmol}^{-1}$  (1) [3]
- (d)  $\Delta H = 2 \times (+23.20) - (-32.60) = +79.00 \text{ kJ mol}^{-1}$  (2) [2]

**[Total: 11]**

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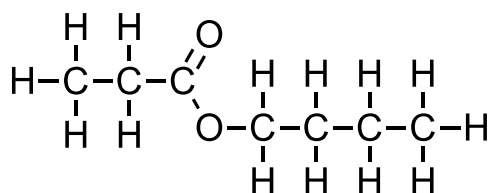
4 (a)



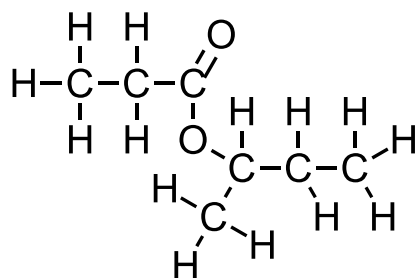
- correct **T** (1)  
 correct **U** (1)  
 correct **V** (1)  
 correct > CO group in **W** (1)  
 correct -CO<sub>2</sub>H group in **W** (1) [5]

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(b) T + U



or



correct structures  
correctly displayed ester group

(1)  
(1) [2]

[Total: 7]

- 5 (a) (i) 1 primary alcohol **not** hydroxyl (1)  
alcohol **not** hydroxyl (1)  
2 aldehyde **not** carbonyl (1)

(ii)

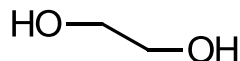
<b>test 1</b>			
reagent	Na	$\text{PCl}_3/\text{PCl}_5/\text{PBr}_3$	$\text{RCO}_2\text{H}/\text{H}^+$
observation	gas/ $\text{H}_2$ /effervescence/ fizzing	$\text{HC}/\text{HBr}$ steamy fumes	fruity smell
<b>test 2</b>			
reagent	Tollens' reagent	Fehling's reagent	2,4-dinitro- phenylhydrazine
observation	Ag mirror/silver/ black ppt	brick-red ppt red ppt	orange/red/yellow ppt/solid

only award the observation mark if reagent is correct

(4) [7]

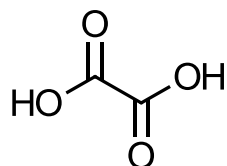
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(b) (i)



(1)

(ii)



(1) [2]

5 (c)

route	starting compound	first reagent	intermediate X	second reagent	intermediate Y	third reagent	final compound
A/1	HOCH <sub>2</sub> CHO	PCl <sub>3</sub> PCl <sub>5</sub> SOCl <sub>2</sub> etc.	ClCH <sub>2</sub> CHO	K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> /H <sup>+</sup> KMnO <sub>4</sub> /H <sup>+</sup> KMnO <sub>4</sub> /OH <sup>-</sup> Tollens' or Fehling's reagents	ClCH <sub>2</sub> CO <sub>2</sub> H	NH <sub>3</sub>	H <sub>2</sub> NCH <sub>2</sub> CO <sub>2</sub> H
A/2	HOCH <sub>2</sub> CHO	HBr P/Br <sub>2</sub> etc.	BrCH <sub>2</sub> CHO	K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> /H <sup>+</sup> KMnO <sub>4</sub> /H <sup>+</sup> KMnO <sub>4</sub> /OH <sup>-</sup> Tollens' or Fehling's reagents	BrCH <sub>2</sub> CO <sub>2</sub> H	NH <sub>3</sub>	H <sub>2</sub> NCH <sub>2</sub> CO <sub>2</sub> H
B/1	HOCH <sub>2</sub> CHO	PCl <sub>3</sub> PCl <sub>5</sub> SOCl <sub>2</sub> etc.	ClCH <sub>2</sub> CHO	NH <sub>3</sub>	H <sub>2</sub> NCH <sub>2</sub> CHO	K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> /H <sup>+</sup> KMnO <sub>4</sub> /H <sup>+</sup> KMnO <sub>4</sub> /OH <sup>-</sup> Tollens' or Fehling's reagents	H <sub>2</sub> NCH <sub>2</sub> CO <sub>2</sub> H
B/2	HOCH <sub>2</sub> CHO	HBr P/Br <sub>2</sub> etc.	BrCH <sub>2</sub> CHO	NH <sub>3</sub>	H <sub>2</sub> NCH <sub>2</sub> CHO	K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> /H <sup>+</sup> KMnO <sub>4</sub> /H <sup>+</sup> KMnO <sub>4</sub> /OH <sup>-</sup> Tollens' or Fehling's reagents	H <sub>2</sub> NCH <sub>2</sub> CO <sub>2</sub> H
C	HOCH <sub>2</sub> CHO	Tollens' or Fehling's reagents	HOCH <sub>2</sub> CO <sub>2</sub> H	KBr/conc. H <sub>2</sub> SO <sub>4</sub>	BrCH <sub>2</sub> CO <sub>2</sub> H	NH <sub>3</sub>	H <sub>2</sub> NCH <sub>2</sub> CO <sub>2</sub> H
mark		(1)	(1)	(1)	(1)	(1)	

[5]

[Total: 14]