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

9701/21 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.

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UNIVERSITY of CAMBRIDGE
International Examinations

1 (a) (i) mass of C = $\frac{12 \times 0.352}{44}$ = 0.096g (1)

n(C) = $\frac{0.096}{12}$ = 0.008 (1)

(ii) mass of H = $\frac{2 \times 0.144}{18}$ = 0.016g (1)

n(H) = $\frac{0.016}{1}$ = 0.016 (1)

(iii) mass of oxygen = 0.240 – (0.096 + 0.016) = 0.128g (1)

n(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 C H_2O (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) $C_2H_4O_2$ (1) [3]

(d) CH_3CO_2H (1)

HCO_2CH_3 (1) [2]

(e) the only products of the reaction are the two oxides H_2O and CO_2 and copper (1) [1]

[Total: 13]

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 A*l***
in Mg outermost electron is in 3s **and**
in A*l* 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	A*l*	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]

3 **(a)** the overall enthalpy change/energy change/ΔH 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 × c × δT = 30.0 × 4.18 × 5.2
= 652.08 J per 0.0200 mol of K_2CO_3 (1)

(iii) 0.020 mol $K_2CO_3 \equiv$ 652.08 J

1 mol $K_2CO_3 \equiv \frac{652.08 \times 1}{0.0200}$ = 32604 J

enthalpy change = –32.60 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 × c × δT = 30.0 × 4.18 × 3.7
= 463.98 J per 0.0200 mol of $KHCO_3$ (1)

(iii) 0.020 mol $KHCO_3 \equiv$ 463.98 J

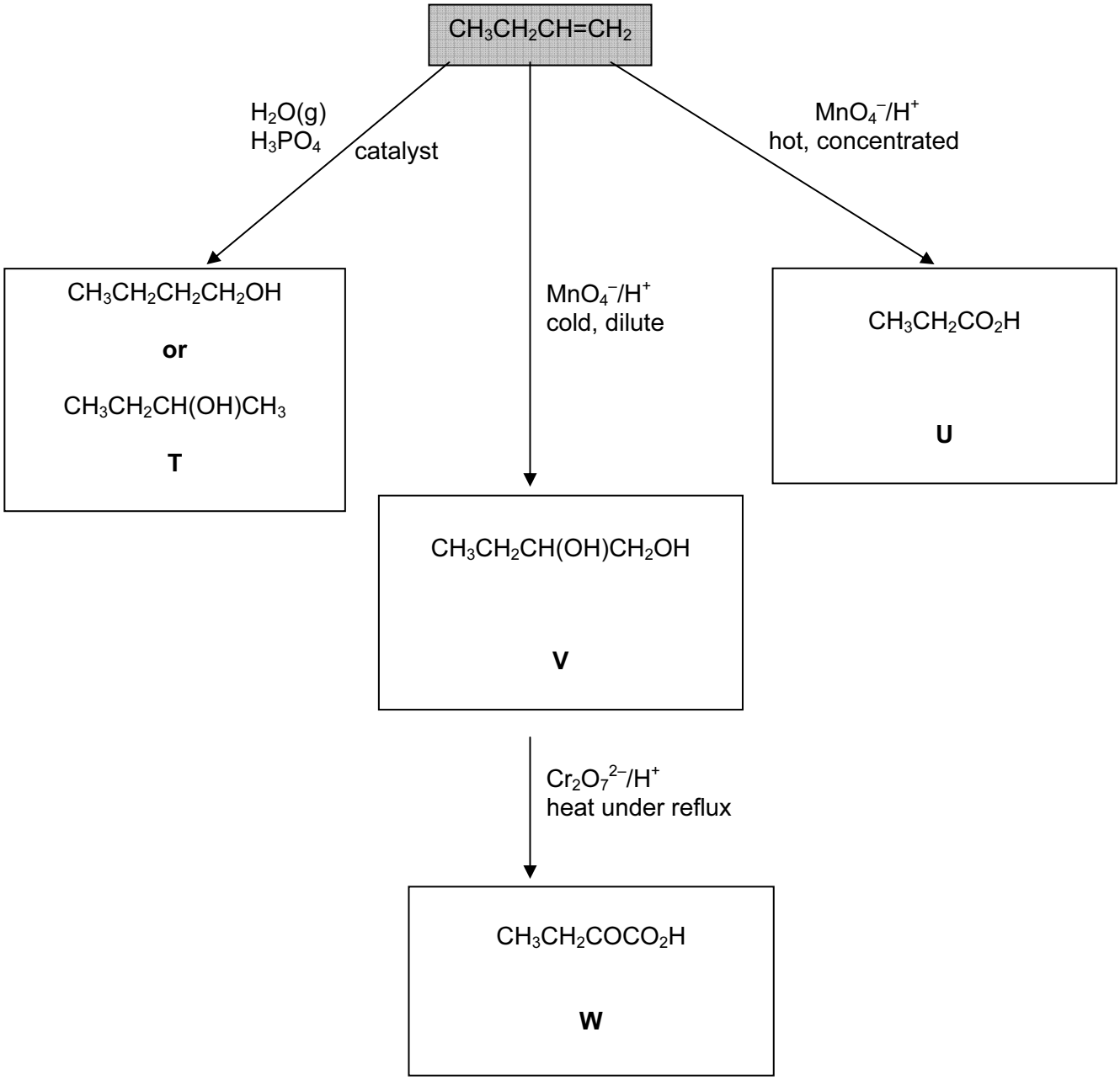
1 mol $KHCO_3 \equiv \frac{463.98 \times 1}{0.0200}$ = 23199 J

enthalpy change = +23.20 kJmol^{-1} (1) [3]

(d) ΔH = 2 × (+23.20) – (–32.60) = +79.00 kJ mol^{-1} (2) [2]

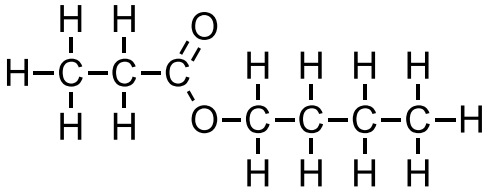
[Total: 11]

4 (a)

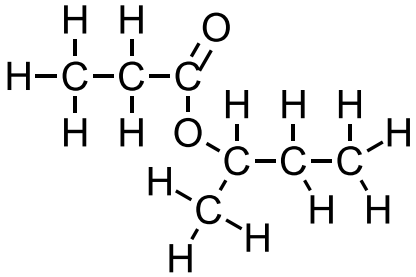


correct **T** (1)
correct **U** (1)
correct **V** (1)
correct > CO group in **W** (1)
correct $-CO_2H$ group in **W** (1) [5]

(b) T + U



or



correct structures (1)
correctly displayed ester group (1) [2]

[Total: 7]

5 (a) (i) 1 primary (1)
alcohol **not** hydroxyl (1)

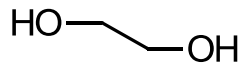
2 aldehyde **not** carbonyl (1)

(ii)

test 1			
reagent	Na	$PCl_3/PCl_5/PBr_3$	RCO_2H/H^+
observation	gas/H_2/effervescence/ fizzing	HCl/HBr steamy fumes	fruity smell
test 2			
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

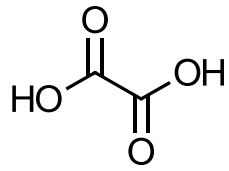
only award the observation mark if reagent is correct (4) [7]

(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	$HOCH_2CHO$	PCl_3 PCl_5 $SOCl_2$ etc.	$ClCH_2CHO$	$K_2Cr_2O_7/H^+$ $KMnO_4/H^+$ $KMnO_4/OH^-$ Tollens' or Fehling's reagents	$ClCH_2CO_2H$	NH_3	$H_2NCH_2CO_2H$
A/2	$HOCH_2CHO$	HBr P/Br_2 etc.	$BrCH_2CHO$	$K_2Cr_2O_7/H^+$ $KMnO_4/H^+$ $KMnO_4/OH^-$ Tollens' or Fehling's reagents	$BrCH_2CO_2H$	NH_3	$H_2NCH_2CO_2H$
B/1	$HOCH_2CHO$	PCl_3 PCl_5 $SOCl_2$ etc.	C/CH_2CHO	NH_3	H_2NCH_2CHO	$K_2Cr_2O_7/H^+$ $KMnO_4/H^+$ $KMnO_4/OH^-$ Tollens' or Fehling's reagents	$H_2NCH_2CO_2H$
B/2	$HOCH_2CHO$	HBr P/Br_2 etc.	$BrCH_2CHO$	NH_3	H_2NCH_2CHO	$K_2Cr_2O_7/H^+$ $KMnO_4/H^+$ $KMnO_4/OH^-$ Tollens' or Fehling's reagents	$H_2NCH_2CO_2H$
C	$HOCH_2CHO$	Tollens' or Fehling's reagents	$HOCH_2CO_2H$	KBr/conc. H_2SO_4	$BrCH_2CO_2H$	NH_3	$H_2NCH_2CO_2H$
mark		(1)	(1)	(1)	(1)	(1)	

[5]

[Total: 14]