**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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**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/$\Delta H$ 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 × c × $\delta$T = 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 × $\delta$T = 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

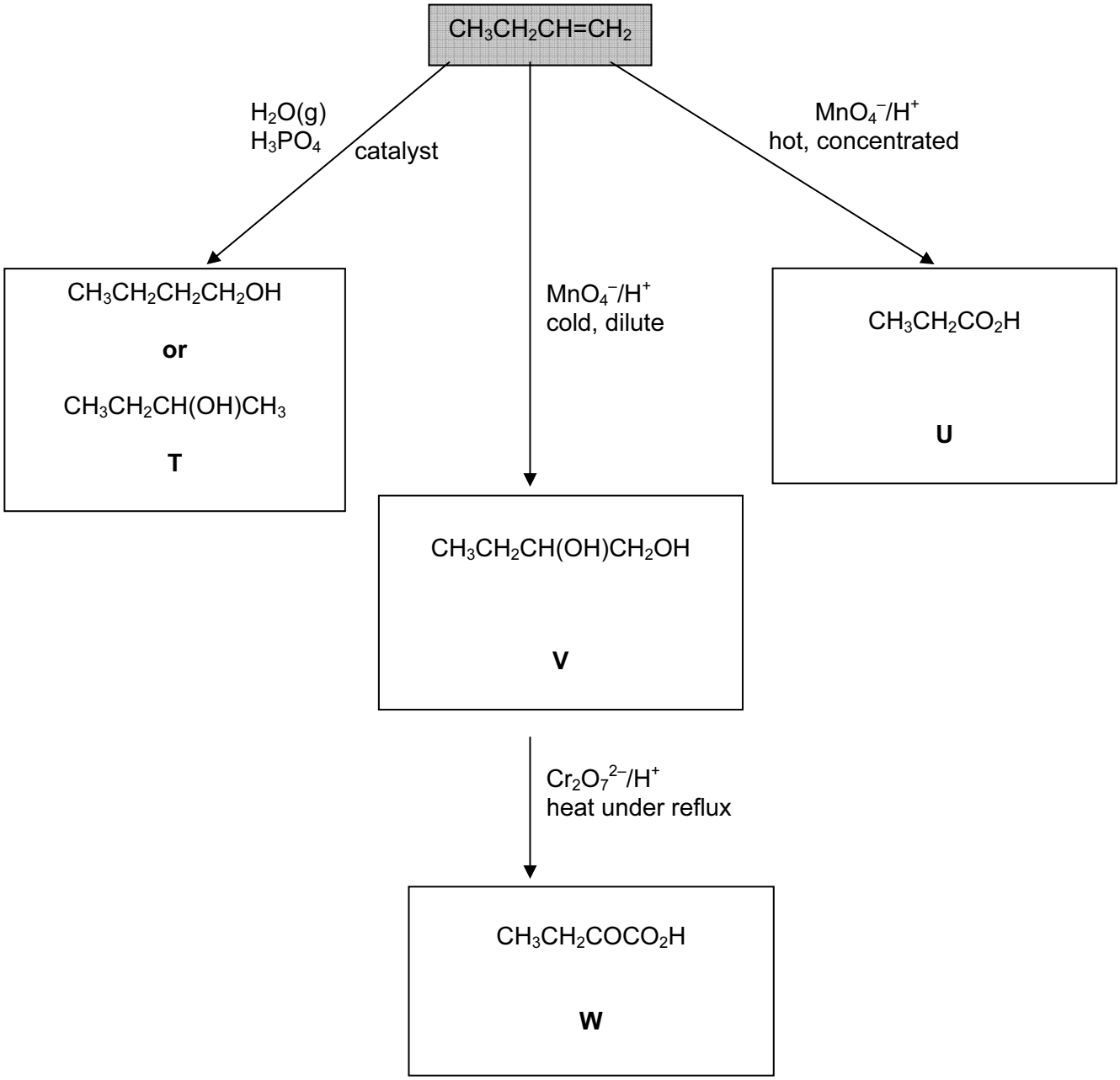
1 mol $KHCO_3 \equiv \frac{463.98 \times 1}{0.0200}$ = 23199 J

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

**(d)** $\Delta H$ = 2 × (+23.20) – (–32.60) = +79.00 kJ mol$^{-1}$ (2) [2]

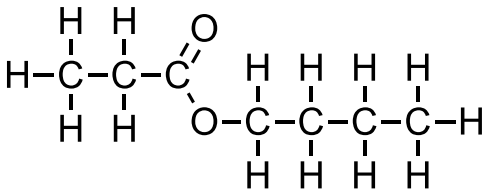
**[Total: 11]**

**4 (a)**

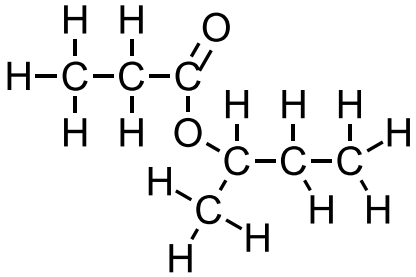



correct **T** (1)
correct **U** (1)
correct **V** (1)
correct > CO group in **W** (1)
correct $-CO_2H$ group in **W** (1) [5]

**(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)

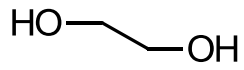
**2** aldehyde **not** carbonyl (1)

**(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 |

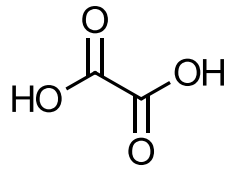
only award the observation mark if reagent is correct (4) [7]

**(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** | $HOCH_2CHO$ | $PCl_3$<br>$PCl_5$<br>$SOCl_2$<br>etc. | $ClCH_2CHO$ | $K_2Cr_2O_7/H^+$<br>$KMnO_4/H^+$<br>$KMnO_4/OH^-$<br>Tollens' or Fehling's reagents | $ClCH_2CO_2H$ | $NH_3$ | $H_2NCH_2CO_2H$ |
| **A/2** | $HOCH_2CHO$ | HBr<br>$P/Br_2$<br>etc. | $BrCH_2CHO$ | $K_2Cr_2O_7/H^+$<br>$KMnO_4/H^+$<br>$KMnO_4/OH^-$<br>Tollens' or Fehling's reagents | $BrCH_2CO_2H$ | $NH_3$ | $H_2NCH_2CO_2H$ |
| **B/1** | $HOCH_2CHO$ | $PCl_3$<br>$PCl_5$<br>$SOCl_2$<br>etc. | $C/CH_2CHO$ | $NH_3$ | $H_2NCH_2CHO$ | $K_2Cr_2O_7/H^+$<br>$KMnO_4/H^+$<br>$KMnO_4/OH^-$<br>Tollens' or Fehling's reagents | $H_2NCH_2CO_2H$ |
| **B/2** | $HOCH_2CHO$ | HBr<br>$P/Br_2$<br>etc. | $BrCH_2CHO$ | $NH_3$ | $H_2NCH_2CHO$ | $K_2Cr_2O_7/H^+$<br>$KMnO_4/H^+$<br>$KMnO_4/OH^-$<br>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]**