UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2012 question paper

for the guidance of teachers

9701 CHEMISTRY

9701/23 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

1 (a) (i) from Na to C*l*

nuclear charge increases (1)
electrons are in the same shell/have the same shielding (1)
nuclear attraction increases (1)

(ii) argon does not form any bonds/compounds **or**
argon exists as single atoms/is monatomic (1) [4]

(b) (i)

radius of cation/nm			radius of anion/nm		
Na^+	Mg^{2+}	Al^{3+}	P^{3-}	S^{2-}	Cl^-
0.095	0.065	0.050	0.212	0.184	0.181

(1)

(ii) cations contain fewer electrons than the corresponding atoms **or**
cations contain fewer electrons than they do protons (1)
nucleus has a greater attraction (1)

(iii) anions contain more electrons than the corresponding atoms **or**
anions contain more electrons than they do protons (1)
nucleus has a smaller attraction (1) [5]

(c) (i) $Na_2O + H_2O \rightarrow 2NaOH$ (1)
$SO_2 + H_2O \rightarrow H_2SO_3$ (1)

(ii) for Na_2O 10 to 14 (1)
for SO_2 1 to 4 (1)

(iii) $NaOH + H_2SO_3 \rightarrow NaHSO_3 + H_2O$ **or**
$2NaOH + H_2SO_3 \rightarrow Na_2SO_3 + 2H_2O$ (1) [5]

[Total: 14]

2 (a) (i) $Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$ (1)

(ii) $n(HCl) = \frac{35.8}{1000} \times 0.100 = 3.58 \times 10^{-3}$ (1)

(iii) $n(Na_2CO_3) = \frac{35.8}{2} \times 10^{-3} = 1.79 \times 10^{-3}$ mol in 25.0 cm^3 (1)

(iv) $n(Na_2CO_3) = 1.79 \times 10^{-3} \times 10 = 1.79 \times 10^{-2}$ mol in 250 cm^3 (1)

(v) mass of $Na_2CO_3 = 1.79 \times 10^{-2} \times 106 = 1.90$g
M_r of $Na_2CO_3 = 106$ (1)
mass of $Na_2CO_3 = 1.90$ g (1) [6]

(b) $n(H_2O)$ in 5.13 g of washing soda $= \frac{5.13 - 1.90}{18} = 1.79 \times 10^{-1}$ mol (1)

$n(Na_2CO_3)$ in 5.13 g of washing soda $= 1.79 \times 10^{-2}$ mol
$n(H_2O) : n(Na_2CO_3) = 10 : 1$ (1)

or
1.90 g Na_2CO_3 are combined with 3.23.g H_2O
106 g Na_2CO_3 are combined with $\frac{3.23 \times 106}{1.90} = 180.2$ g H_2 (1)
this is 10 mol of H_2O (1)

or
1.79×10^{-2} mol $Na_2CO_3.xH_2O \equiv 5.13$ g of washing soda
1 mol $Na_2CO_3.xH_2O \equiv \frac{5.13}{1.79 \times 10^{-2}} = 286.6$ g (1)
$Na_2CO_3 = 106$ and $H_2O = 18$ hence $x = 10$ (1) [2]

[Total: 8]

3 **(a)** $CH_3OCH_3(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ (1)

the enthalpy change/heat change/heat evolved when

one mole of CH_3OCH_3/a compound (1)

is completely burned **or**

burned in an excess of air/oxygen (1) [3]

(b)

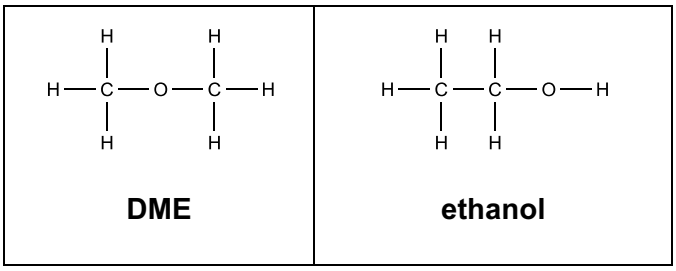
	$2CH_3OH(l)$	$\rightarrow$	$CH_3OCH_3(g)$	+	$H_2O(l)$
$\Delta H^{\ominus}_f$/kJ mol^{-1}	2(–239)		–184		–286

$\Delta H^{\ominus}_{reaction}$ = –184 + (–286) – 2(–239) (1)

= +8 kJ mol^{-1} (1)

correct sign (1) [3]

(c) **(i)**



both correct (1)

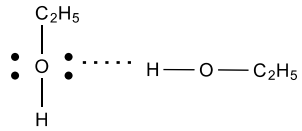
(ii) structural isomerism **or** functional group isomerism (1) [2]

(d) **(i)** hydrogen bonds (1)

(ii) lone pair on O atom of C_2H_5OH (1)

correct dipole $O^{\delta-}$—$H^{\delta+}$ on bond in one molecule of ethanol (1)

hydrogen bond shown between lone pair of an O atom and a hydrogen atom, i.e.



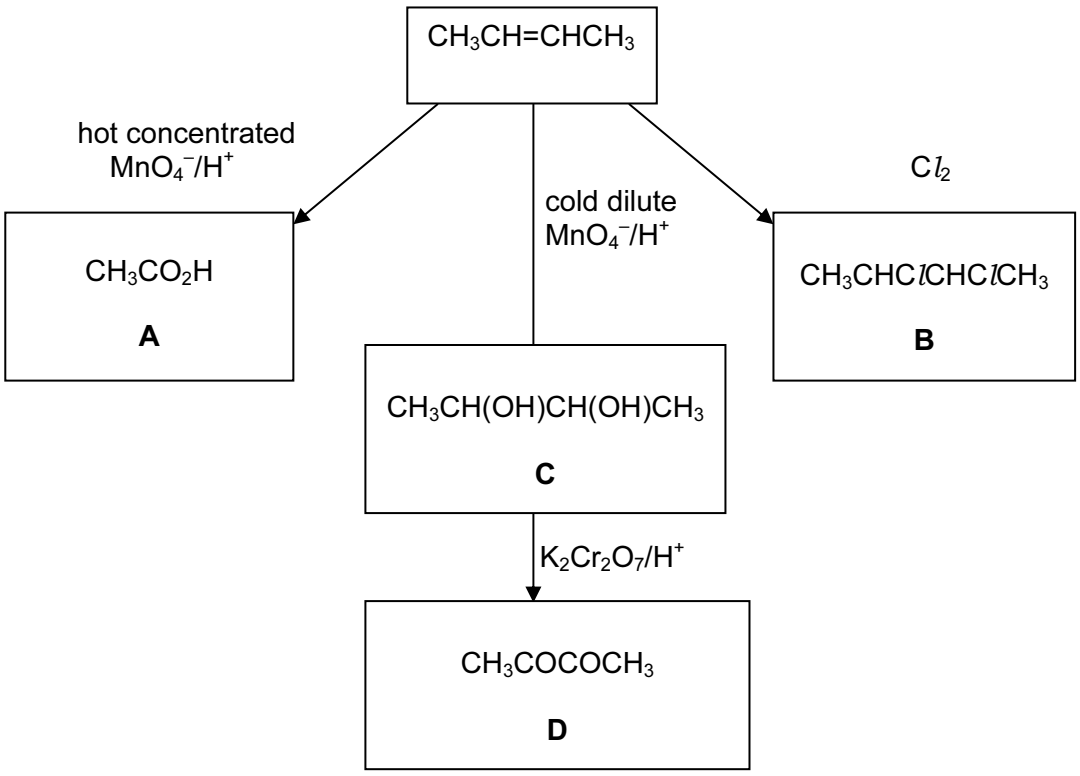
(1) [4]

[Total: 12]

4 **(a)** high temperature and high pressure (1)
high temperature and catalyst (1) [2]

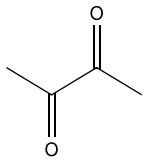
(b) $C_{12}H_{26} \rightarrow C_4H_8 + C_8H_{18}$ **or**
$C_{12}H_{26} \rightarrow 2C_4H_8 + C_4H_{10}$ (1) [1]

(c)



(4 × 1) [4]

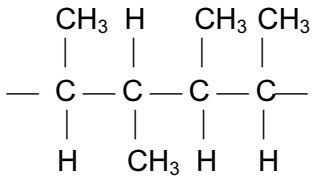
(d) **(i)**



(1)

(ii) compound **B** (1)
compound **C** (1) [3]

(e)



allow any orientation of CH_3– groups (1) [1]

(f) **(i)** $CH_2=CH—CH=CH_2$
allow $CH_3CHOHCH=CH_2$ and $CH_3C\equiv CCH_3$ (1)

(ii) $CH_2BrCHBrCHBrCH_2Br$
allow $CH_3CBr_2CBr_2CH_3$ from $CH_3CHOHCH=CH_2$
allow $CH_3CHOHCHBrCH_2Br$ from $CH_3C\equiv CCH_3$ (1)

(iii) electrophilic addition
both words required (1) [3]

[Total: 14]

5 (a) (i) CO_2/carbon dioxide (1)

(ii) carboxylic acid **or** $–CO_2H$ **or** –COOH (1) [2]

(b) (i) dehydration **or** elimination (1)

(ii) **H** contains >C=C< bond (1)
H contains $–CO_2H$ group (1)
H is $CH_2=CHCO_2H$ (1) [4]

(c) $n(\mathbf{F}) = \frac{0.600}{90} = 6.67 \times 10^{-3}$ mol (1)

F contains one –OH group and one $–CO_2H$ group
hence one mole of **F** produces one mole of H_2 with Na (1)
$n(H_2) = 6.67 \times 10^{-3}$ mol (1)
vol. of $H_2 = 6.67 \times 10^{-3} \times 24000$ cm^3
= 160 cm^3 at room temperature and pressure (1)
[4]

(d) (i)

$HOCH_2CH_2CO_2H$	$CH_3CH(OH)CO_2H$
J	**K**

one isomer correct (1)

(ii)

$HO_2CCH_2CO_2H$	CH_3COCO_2H
product from J	**product from K**

one oxidation product correct (1) [2]

[Total: 12]