**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

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**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]**

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**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
$1.79 \times 10^{-2}$ 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]**

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**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)**

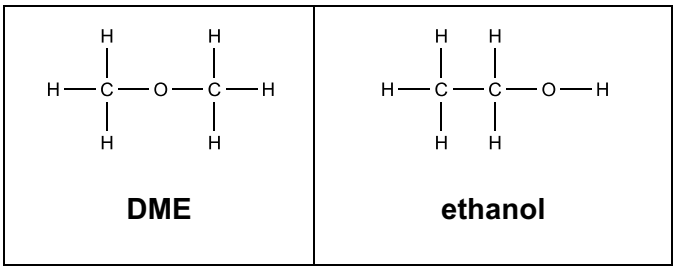
| | $2CH_3OH(l)$ | $\rightarrow$ | $CH_3OCH_3(g)$ | + | $H_2O(l)$ |
|---|---|---|---|---|---|
| $\Delta H^{\ominus}_f$/kJ mol$^{-1}$ | 2(–239) | | –184 | | –286 |

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

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

correct sign (1) [3]

**(c)** **(i)**




**both** correct (1)

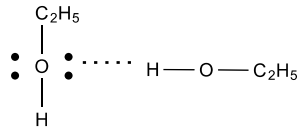
**(ii)** structural isomerism **or** functional group isomerism (1) [2]

**(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]**

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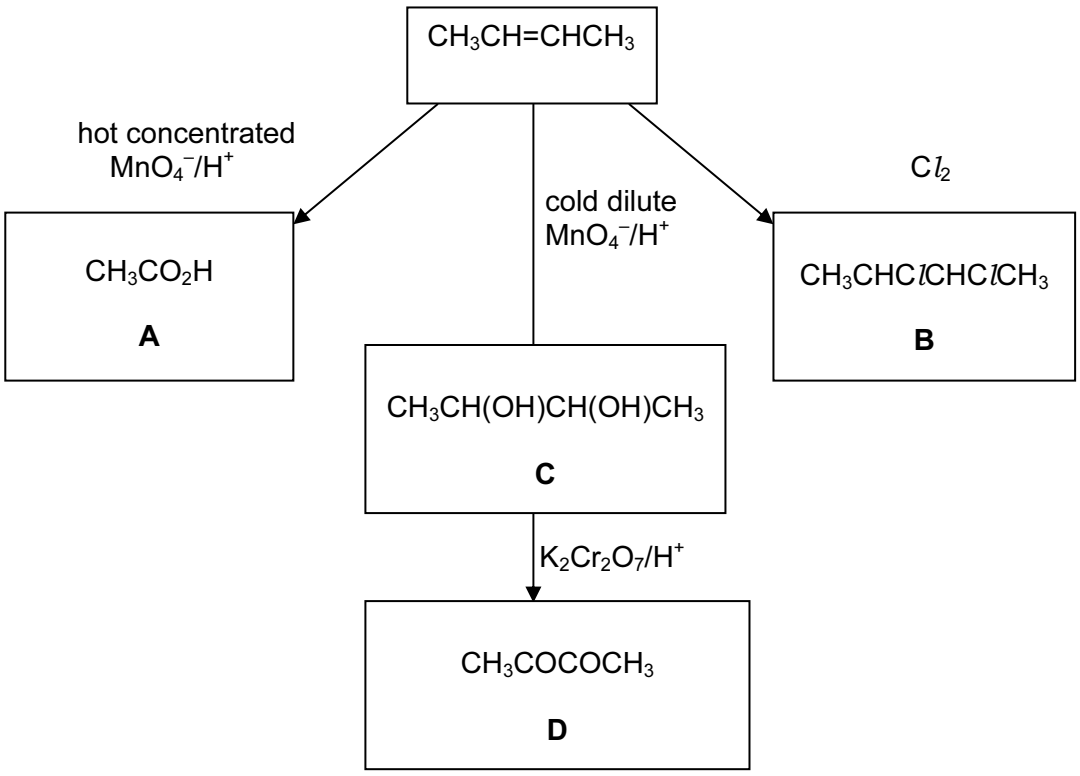
**4** **(a)** high temperature and high pressure (1)
high temperature and catalyst (1) [2]

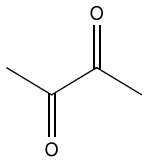
**(b)** $C_{12}H_{26} \rightarrow C_4H_8 + C_8H_{18}$ **or**
$C_{12}H_{26} \rightarrow 2C_4H_8 + C_4H_{10}$ (1) [1]

**(c)**




(4 × 1) [4]

**(d)** **(i)**




(1)

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

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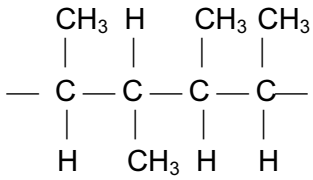
**(e)**



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]**

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**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]**

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