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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.

Mark schemes must be read in conjunction with the question papers and the report on the examination.

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Cambridge is publishing the mark schemes for the May/June 2012 question papers for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level syllabuses and some Ordinary Level syllabuses.

Page 2	Mark Scheme: Teachers' version	Syllabus	Paper
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- 1 (a) (i) from Na to Cl
- 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) $\text{Na}_2\text{O} + \text{H}_2\text{O} \rightarrow 2\text{NaOH}$ (1)
 $\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3$ (1)
- (ii) for Na₂O 10 to 14 (1)
for SO₂ 1 to 4 (1)
- (iii) $\text{NaOH} + \text{H}_2\text{SO}_3 \rightarrow \text{NaHSO}_3 + \text{H}_2\text{O}$ **or** $2\text{NaOH} + \text{H}_2\text{SO}_3 \rightarrow \text{Na}_2\text{SO}_3 + 2\text{H}_2\text{O}$ (1) [5]

[Total: 14]

Page 3	Mark Scheme: Teachers' version	Syllabus	Paper
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- 2 (a) (i) $\text{Na}_2\text{CO}_3 + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{H}_2\text{O} + \text{CO}_2$ (1)
- (ii) $n(\text{HCl}) = \frac{35.8}{1000} \times 0.100 = 3.58 \times 10^{-3}$ (1)
- (iii) $n(\text{Na}_2\text{CO}_3) = \frac{35.8}{2} \times 10^{-3} = 1.79 \times 10^{-3} \text{ mol in } 25.0 \text{ cm}^3$ (1)
- (iv) $n(\text{Na}_2\text{CO}_3) = 1.79 \times 10^{-3} \times 10 = 1.79 \times 10^{-2} \text{ mol in } 250 \text{ cm}^3$ (1)
- (v) mass of $\text{Na}_2\text{CO}_3 = 1.79 \times 10^{-2} \times 106 = 1.90 \text{ g}$ (1)
 M_r of $\text{Na}_2\text{CO}_3 = 106$ (1)
mass of $\text{Na}_2\text{CO}_3 = 1.90 \text{ g}$ (1) [6]
- (b) $n(\text{H}_2\text{O})$ in 5.13 g of washing soda $= \frac{5.13 - 1.90}{18} = 1.79 \times 10^{-1} \text{ mol}$ (1)
 $n(\text{Na}_2\text{CO}_3)$ in 5.13 g of washing soda $= 1.79 \times 10^{-2} \text{ mol}$
 $n(\text{H}_2\text{O}) : n(\text{Na}_2\text{CO}_3) = 10 : 1$ (1)
- or
1.90 g Na_2CO_3 are combined with 3.23 g H_2O
106 g Na_2CO_3 are combined with $\frac{3.23 \times 106}{1.90} = 180.2 \text{ g H}_2\text{O}$ (1)
this is 10 mol of H_2O (1)
- or
 $1.79 \times 10^{-2} \text{ mol Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O} \equiv 5.13 \text{ g of washing soda}$
 $1 \text{ mol Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O} \equiv \frac{5.13}{1.79 \times 10^{-2}} = 286.6 \text{ g}$ (1)
 $\text{Na}_2\text{CO}_3 = 106$ and $\text{H}_2\text{O} = 18$ hence $x = 10$ (1) [2]

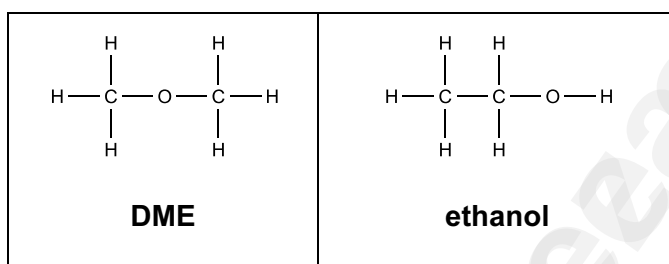
[Total: 8]

Page 4	Mark Scheme: Teachers' version	Syllabus	Paper
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- 3 (a) $\text{CH}_3\text{OCH}_3(\text{l}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\text{l})$ (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)
$$\begin{array}{rcll} 2\text{CH}_3\text{OH}(\text{l}) & \rightarrow & \text{CH}_3\text{OCH}_3(\text{g}) & + \text{H}_2\text{O}(\text{l}) \\ \Delta H_f^\circ / \text{kJ mol}^{-1} & & -184 & -286 \\ \Delta H_{\text{reaction}}^\circ & = & -184 + (-286) - 2(-239) & (1) \\ & = & +8 \text{ kJ mol}^{-1} & (1) \\ \text{correct sign} & & & (1) \end{array}$$
 [3]

- (c) (i)



both correct (1)

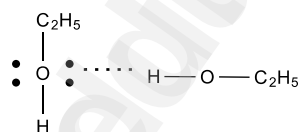
- (ii) structural isomerism **or** functional group isomerism (1) [2]

- (d) (i) hydrogen bonds (1)

- (ii) lone pair on O atom of $\text{C}_2\text{H}_5\text{OH}$ (1)

correct dipole $\text{O}^{\delta-}-\text{H}^{\delta+}$ 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]

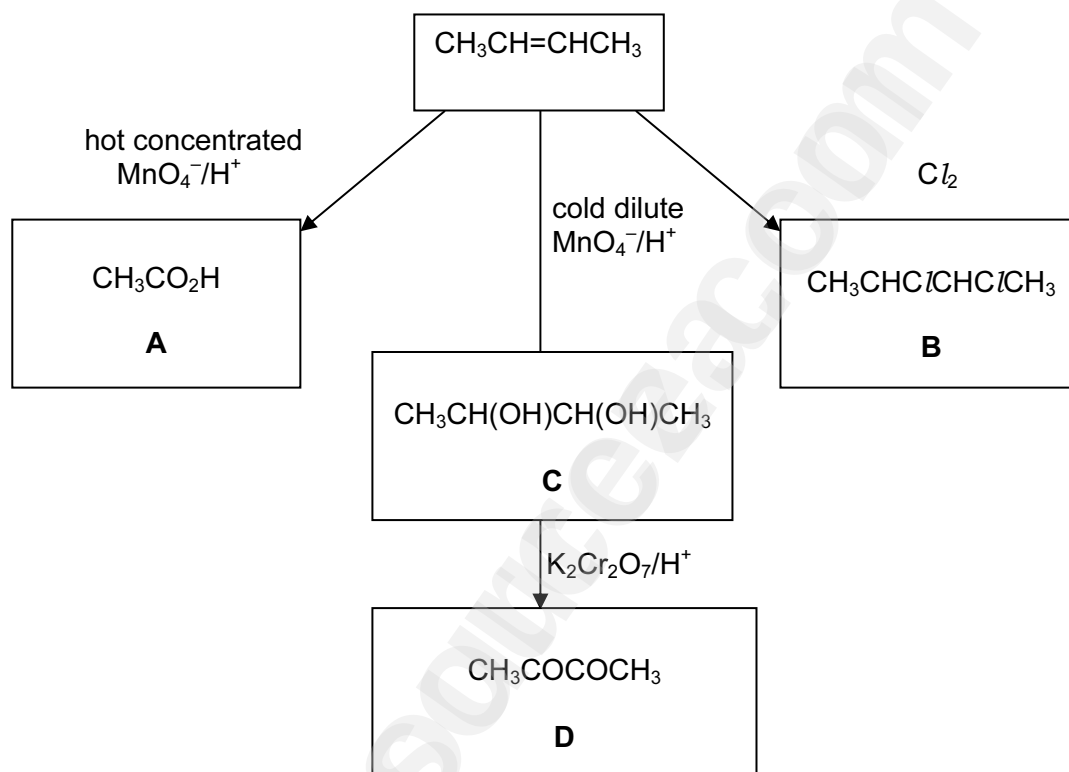
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Page 5	Mark Scheme: Teachers' version	Syllabus	Paper
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- 4 (a) high temperature and high pressure (1)
 high temperature and catalyst (1) [2]

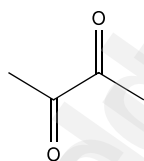
- (b) $C_{12}H_{26} \rightarrow C_4H_8 + C_8H_{18}$ or
 $C_{12}H_{26} \rightarrow 2C_4H_8 + C_4H_{10}$ (1) [1]

(c)



(4 × 1) [4]

(d) (i)



(1)

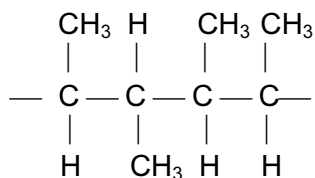
- (ii) compound **B**
 compound **C**

(1)

(1) [3]

Page 6	Mark Scheme: Teachers' version	Syllabus	Paper
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(e)



allow any orientation of CH₃– groups

(1) [1]

(f) (i) CH₂=CH—CH=CH₂

allow CH₃CHOHCH=CH₂ and CH₃C≡CCH₃

(1)

(ii) CH₂BrCHBrCHBrCH₂Br

allow CH₃CBr₂CBr₂CH₃ from CH₃CHOHCH=CH₂

allow CH₃CHOHCHBrCH₂Br from CH₃C≡CCH₃

(1)

(iii) electrophilic addition

both words required

(1) [3]

[Total: 14]

Page 7	Mark Scheme: Teachers' version	Syllabus	Paper
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- 5 (a) (i) CO₂/carbon dioxide (1)
- (ii) carboxylic acid **or** –CO₂H **or** –COOH (1) [2]

- (b) (i) dehydration **or** elimination (1)
- (ii) H contains >C=C< bond (1)
H contains –CO₂H group (1)
H is CH₂=CHCO₂H (1) [4]

- (c) $n(\text{F}) = \frac{0.600}{90} = 6.67 \times 10^{-3} \text{ mol}$ (1)
- F contains one –OH group and one –CO₂H group (1)
hence one mole of F produces one mole of H₂ with Na (1)
 $n(\text{H}_2) = 6.67 \times 10^{-3} \text{ mol}$ (1)
vol. of H₂ = $6.67 \times 10^{-3} \times 24000 \text{ cm}^3$ (1)
= 160 cm³ at room temperature and pressure (1) [4]

- (d) (i)

HOCH ₂ CH ₂ CO ₂ H	CH ₃ CH(OH)CO ₂ H
J	K

one isomer correct (1)

- (ii)

HO ₂ CCH ₂ CO ₂ H	CH ₃ COCO ₂ H
product from J	product from K

one oxidation product correct (1) [2]

[Total: 12]