

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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**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 <sup>+</sup>	Mg <sup>2+</sup>	Al <sup>3+</sup>	P <sup>3-</sup>	S <sup>2-</sup>	Cl <sup>-</sup>
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 Na<sub>2</sub>O 10 to 14 (1)  
 for SO<sub>2</sub> 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  $\text{Na}_2\text{CO}_3 = 1.79 \times 10^{-2} \times 106 = 1.90 \text{ g}$   
 $M_r$  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  $\text{Na}_2\text{CO}_3$  are combined with 3.23 g  $\text{H}_2\text{O}$   
 106 g  $\text{Na}_2\text{CO}_3$  are combined with  $\frac{3.23 \times 106}{1.90} = 180.2 \text{ g H}_2\text{O}$  (1)  
 this is 10 mol of  $\text{H}_2\text{O}$  (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]

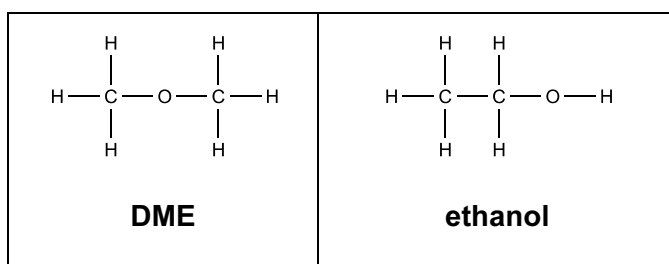
**[Total: 8]**

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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  $\text{CH}_3\text{OCH}_3$ /a compound (1)  
is completely burned **or**  
burned in an excess of air/oxygen (1) [3]

- (b) 
$$\begin{array}{rclcl} 2\text{CH}_3\text{OH}(\text{l}) & \rightarrow & \text{CH}_3\text{OCH}_3(\text{g}) & + & \text{H}_2\text{O}(\text{l}) \\ \Delta H^\circ_{\text{f}}/\text{kJ mol}^{-1} & & -184 & & -286 \\ & & 2(-239) & & \\ \Delta H^\circ_{\text{reaction}} & = & -184 + (-286) - 2(-239) & & (1) \\ & = & +8 \text{ kJ mol}^{-1} & & (1) \\ \text{correct sign} & & & & (1) \end{array}$$
 [3]

- (c) (i)



**both** correct (1)

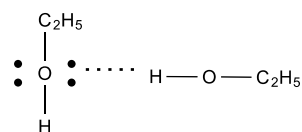
- (ii) structural isomerism **or** functional group isomerism (1) [2]

- (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]

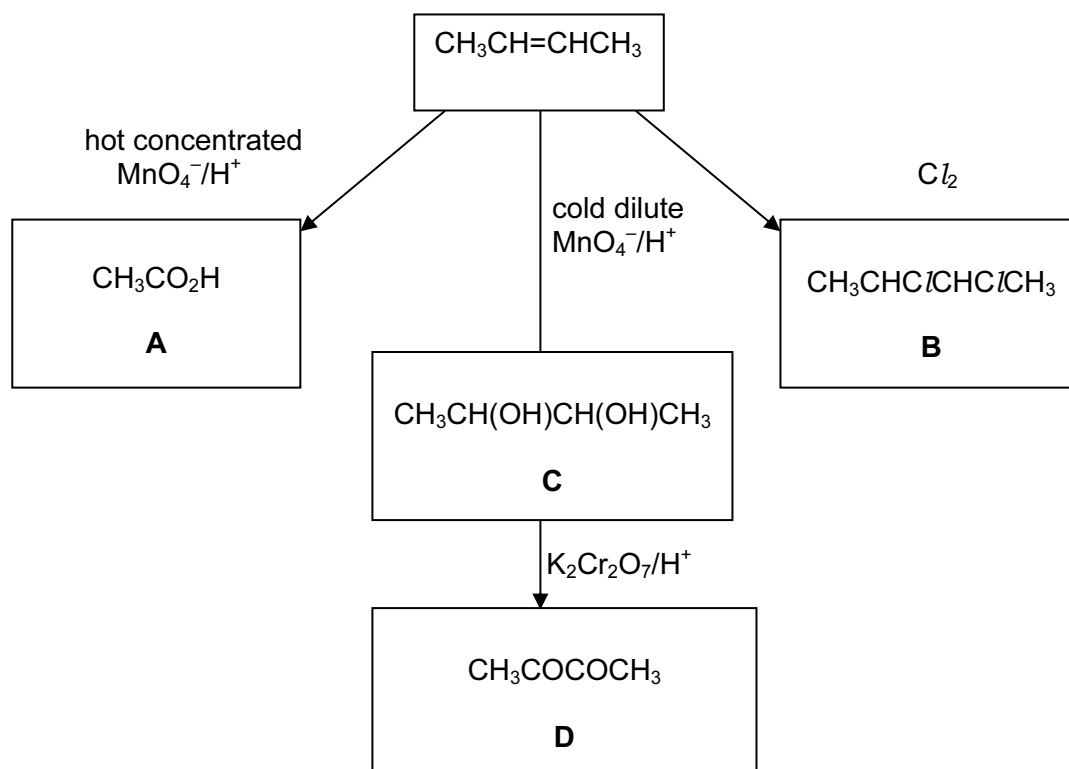
**[Total: 12]**

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]

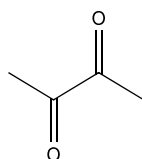
- (b)  $C_{12}H_{26} \rightarrow C_4H_8 + C_8H_{18}$  or  
 $C_{12}H_{26} \rightarrow 2C_4H_8 + C_4H_{10}$  (1) [1]

(c)



(4 × 1) [4]

(d) (i)



(1)

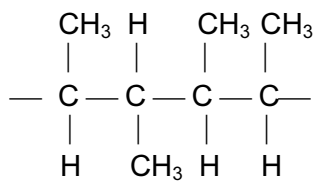
- (ii) compound **B**  
 compound **C**

(1)

(1) [3]

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(e)



allow any orientation of CH<sub>3</sub>– groups

(1) [1]

(f) (i) CH<sub>2</sub>=CH—CH=CH<sub>2</sub>

allow CH<sub>3</sub>CHOHCH=CH<sub>2</sub> and CH<sub>3</sub>C≡CCH<sub>3</sub>

(1)

(ii) CH<sub>2</sub>BrCHBrCHBrCH<sub>2</sub>Br

allow CH<sub>3</sub>CBr<sub>2</sub>CBr<sub>2</sub>CH<sub>3</sub> from CH<sub>3</sub>CHOHCH=CH<sub>2</sub>

allow CH<sub>3</sub>CHOHCHBrCH<sub>2</sub>Br from CH<sub>3</sub>C≡CCH<sub>3</sub>

(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) CO<sub>2</sub>/carbon dioxide (1)
- (ii) carboxylic acid **or** –CO<sub>2</sub>H **or** –COOH (1) [2]

- (b) (i) dehydration **or** elimination (1)
- (ii) H contains >C=C< bond (1)  
H contains –CO<sub>2</sub>H group (1)  
H is CH<sub>2</sub>=CHCO<sub>2</sub>H (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 –CO<sub>2</sub>H group (1)  
hence one mole of F produces one mole of H<sub>2</sub> with Na (1)  
 $n(\text{H}_2) = 6.67 \times 10^{-3} \text{ mol}$  (1)  
vol. of H<sub>2</sub> =  $6.67 \times 10^{-3} \times 24000 \text{ cm}^3$  (1)  
= 160 cm<sup>3</sup> at room temperature and pressure (1) [4]

- (d) (i)

HOCH <sub>2</sub> CH <sub>2</sub> CO <sub>2</sub> H	CH <sub>3</sub> CH(OH)CO <sub>2</sub> H
<b>J</b>	<b>K</b>

one isomer correct (1)

- (ii)

HO <sub>2</sub> CCH <sub>2</sub> CO <sub>2</sub> H	CH <sub>3</sub> COCO <sub>2</sub> H
<b>product from J</b>	<b>product from K</b>

**one** oxidation product correct (1) [2]

[Total: 12]