

**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**

**9701/21**

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.

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1 (a)

Na <sub>2</sub> O	MgO	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	P <sub>4</sub> O <sub>10</sub>	SO <sub>2</sub>	Cl <sub>2</sub> O <sub>7</sub>
alkaline	basic	amphoteric	acidic	acidic	acidic	acidic

Na<sub>2</sub>O is alkaline – allow basic (1)

MgO is basic – allow alkaline (1)

Al<sub>2</sub>O<sub>3</sub> is amphoteric (1)

SiO<sub>2</sub>, P<sub>4</sub>O<sub>10</sub>, and SO<sub>2</sub> are **all** acidic (1) [4]

(b) any **two** from:  
sodium, phosphorus, sulfur and chlorine  
**two names** required (1) [1]

(c) (i) any **three** from:  
floats  
vigorous/violent reaction occurs  
melts/forms a sphere  
moves  
disappears – allow dissolves  
effervescence/gas produced (any 3)

(ii) Na + H<sub>2</sub>O → NaOH + ½H<sub>2</sub>  
**or**  
2Na + 2H<sub>2</sub>O → 2NaOH + H<sub>2</sub> (1) [4]

(d) (i) combustion of fossil fuels – e.g. from car engines  
from car exhausts **or**  
during the extraction of metals from sulfide ores or  
volcanic eruptions/burning sulfur from volcanoes or  
burning biomass (1)

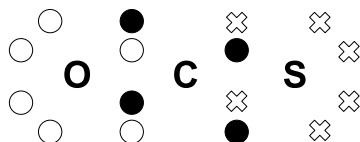
(ii) H<sub>2</sub>SO<sub>4</sub>  
**or**  
SO<sub>3</sub> allow H<sub>2</sub>SO<sub>3</sub> **formula required** (1)

(iii) acid rain  
**or**  
its consequences e.g. damage to buildings,  
damage to crops, plants, marine life  
deforestation  
**or**  
SO<sub>3</sub> is toxic (1) [3]

(e) it is a reducing agent/antioxidant  
**or**  
it kills bacteria (1) [1]

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(f) (i)

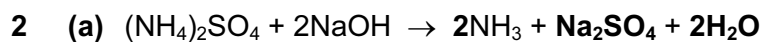


(1)

(ii)  $180^\circ$

(1) [2]

[Total: 15]



correct products

(1)

correctly balanced equation

(1) [2]



(1)

(ii)  $n(\text{HCl}) = \frac{31.2}{1000} \times 1.00 = 0.0312 = 0.03$

(1)

(iii)  $n(\text{NaOH}) = \frac{50.0}{1000} \times 2.00 = 0.10$

(1)

(iv)  $n(\text{NaOH}) \text{ used up} = 0.10 - 0.0312 = 0.0688 = 0.07$

(1)

(v)  $n[(\text{NH}_4)_2\text{SO}_4] = \frac{0.0688}{2} = 0.0344 = 0.03$

(1)

(vi)  $\text{mass of } (\text{NH}_4)_2\text{SO}_4 = 0.0344 \times 132 = 4.5408 = 4.54$

(1)

(vii)  $\text{percentage purity} = \frac{4.5408 \times 100}{5.00} = 90.816 = 90.8$

(1) [7]

[Total: 9]

Page 4	Mark Scheme: Teachers' version	Syllabus	Paper
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- 3 (a)  $\text{C(s)} + \text{O}_2\text{(g)} \rightarrow \text{CO}_2\text{(g)}$  (1)  
the enthalpy change/energy change/heat change when (1)  
one mole of a compound/ $\text{CO}_2$  (1)  
is formed from its elements in their standard states (1) [3]
- (b) (i) 
$$\begin{array}{ccccccc} \Delta H_f^\circ / \text{kJ mol}^{-1} & \text{CO}_2\text{(g)} & + & 3\text{H}_2\text{(g)} & \rightleftharpoons & \text{CH}_3\text{OH(g)} & + & \text{H}_2\text{O(g)} \\ & -394 & & 0 & & -201 & & -242 \end{array}$$
- $\Delta H^\circ_{\text{reaction}} = -201 + (-242) - (-394)$  (1)  
 $-49 \text{ kJ mol}^{-1}$  (1)  
correct sign (1)
- (ii) removal of  $\text{CO}_2$  from the atmosphere (1)  
 $\text{CO}_2$  is a greenhouse gas/causes global warming (1) [5]
- (c) In this part, in each case, the 'effect' must be correctly stated in order to gain the explanation mark.
- higher temperature**  
yield is reduced/equilibrium goes to LHS (1)  
because forward reaction is exothermic/reverse reaction is endothermic (1)
- higher pressure**  
yield is increased **or** equilibrium goes to RHS (1)  
fewer moles/molecules on RHS **or** more moles/molecules on LHS (1)
- use of catalyst**  
yield does not change (1)  
forward and backward rates speeded up by same amount (1) [6]

[Total: 14]

Page 5	Mark Scheme: Teachers' version	Syllabus	Paper
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- 4 (a) (i)  $\text{C}_2\text{H}_5\text{OH} \rightarrow \text{C}_2\text{H}_4 + \text{H}_2\text{O}$  (1)
- (ii) elimination **or** dehydration (1)
- (iii) phosphoric acid **or** concentrated sulfuric acid  
sulfuric acid must be 'concentrated'  
allow aluminium oxide (1) [3]

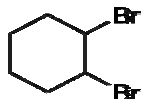
(b)

	with HBr	with $\text{MnO}_4^-$
colour at start	colourless	purple <b>or</b> pink
colour after reaction	colourless	colourless <b>or</b> decolourised
structural formula of product	$\text{CH}_3\text{CH}_2\text{Br}$	$\text{HOCH}_2\text{CH}_2\text{OH}$

**with hydrogen bromide****from** colourless **to** colourless **both** colours required**do not allow** 'clear' instead of colourless (1) $\text{CH}_3\text{CH}_2\text{Br}$  (1)**with potassium manganate(VII)****from** purple/pink **to** colourless/decolourised **both** colours required (1) $\text{HOCH}_2\text{CH}_2\text{OH}$  (1) [4]

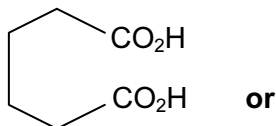
- (c) (i)  $\text{C}_6\text{H}_{10}$  (1)

(ii)

accept answers which have  $-\text{CH}_2-$  in the ring (1)

- (iii) electrophilic addition (1)
- addition (1)

(iv)

 $\text{HO}_2\text{C}(\text{CH}_2)_4\text{CO}_2\text{H}$  **or** $\text{HO}_2\text{CCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$  (1)accept answers which have  $-\text{CH}_2-$  in the ring [5]**[Total: 12]**

Page 6	Mark Scheme: Teachers' version	Syllabus	Paper
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5 (a) carboxylic acid **or**  $\text{--CO}_2\text{H}$  **or**  $\text{--COOH}$  (1) [1]

(b) (i) alcohol (1)

(ii)  $n(\text{H}_2) = \frac{160}{24000} = 6.67 \times 10^{-3} \text{ mol}$  (1)

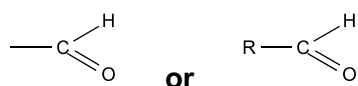
$n(\text{H atoms}) = 2 \times 6.67 \times 10^{-3} \text{ mol} = 1.33 \times 10^{-2} \text{ mol}$  (1)

(iii)  $n(\text{X}) = \frac{0.600}{90} = 6.67 \times 10^{-3} \text{ mol}$

$n(\text{X}) : n(\text{H atoms}) = 6.67 \times 10^{-3} : 1.33 \times 10^{-2}$   
 $= 1 : 2$

since each  $\text{--OH}$  group produces one H atom  
 there are two  $\text{--OH}$  groups (1) [4]

(c) (i)



(1)

(ii)  $\text{HOCH}_2\text{CH}(\text{OH})\text{CHO}$  as the minimum  
 allow the *gem* diols  $(\text{HO})_2\text{CHCH}_2\text{CHO}$  **or**  $\text{CH}_3\text{C}(\text{OH})_2\text{CHO}$  (1)

(iii)  $\text{HOCH}_2\text{CH}(\text{OH})\text{CO}_2\text{H}$  **or**  $\text{HOCH}_2\text{CH}(\text{OH})\text{CO}_2^-$  (1) [3]

(d) (i)  $\text{HOCH}_2\text{CH}(\text{OH})\text{CH}_2\text{OH}$  (1)

(ii)  $\text{HO}_2\text{CCOCO}_2\text{H}$  (1) [2]

**[Total: 10]**