

**CAMBRIDGE INTERNATIONAL EXAMINATIONS**  
GCE Advanced Subsidiary Level and GCE Advanced Level

## **MARK SCHEME for the October/November 2012 series**

### **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.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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Cambridge is publishing the mark schemes for the October/November 2012 series for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level components and some Ordinary Level components.

Page 2	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – October/November 2012	9701	21

- 1 (a)  $\text{ZnCO}_3$      $\text{Zn(OH)}_2$      $\text{ZnO}$   
**not Zn or** other compounds of Zn (any 2) [2]
- (b) (i) to ensure all of the water of crystallisation had been driven off **or**  
to be at constant mass (1)
- (ii) mass of  $\text{ZnSO}_4 = 76.34 - 74.25 = 2.09 \text{ g}$  (1)
- $M_r \text{ ZnSO}_4 = 65.4 + 32.1 + (4 \times 16.0) = 161.5$
- allow use of  $\text{Zn} = 65$  and/or  $\text{S} = 32$  to give values between 161 and 161.5 (1)
- $n(\text{ZnSO}_4) = \frac{2.09}{161.5} = 0.01294 = 1.29 \times 10^{-2}$
- $\text{ZnSO}_4 = 161$  gives  $1.30 \times 10^{-2}$  (1)
- (iii) mass of  $\text{H}_2\text{O}$  driven off =  $77.97 - 76.34 = 1.63 \text{ g}$  (1)
- $n(\text{H}_2\text{O}) = \frac{1.63}{18} = 0.0905 = 9.1 \times 10^{-2}$  (1)
- (iv)  $1.29 \times 10^{-2} \text{ mol ZnSO}_4$  are combined with  $9.1 \times 10^{-2} \text{ mol H}_2\text{O}$
- 1 mol  $\text{ZnSO}_4$  is combined with  $\frac{9.1 \times 10^{-2}}{1.29 \times 10^{-2}}$
- =  $7.054 \approx 7 \text{ mol H}_2\text{O}$
- answer must be expressed as a whole number  
allow ecf on candidate's answers to (b)(ii) and (b)(iii) (1) [7]
- (c) (i)  $n(\text{Zn}) = n(\text{CH}_3\text{CO}_2)_2\text{Zn} \cdot 2\text{H}_2\text{O}$  (1)
- $n(\text{Zn}) = \frac{0.015}{65.4} = 2.290 \times 10^{-4}$
- =  $2.29 \times 10^{-4}$  (1)
- mass of crystals =  $2.29 \times 10^{-4} \times 219.4 = 0.0502655 \text{ g}$   
=  $0.05 \text{ g} = 50 \text{ mg}$  (1)
- (ii) concentration of  $(\text{CH}_3\text{CO}_2)_2\text{Zn} \cdot 2\text{H}_2\text{O} = \frac{2.29 \times 10^{-4}}{0.005} = 0.0458$   
=  $4.58 \times 10^{-2} \text{ mol dm}^{-3}$  (1)
- allow correct answers if  $\text{Zn} = 65$  is used [4]

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Page 3	Mark Scheme	Syllabus	Paper
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- 2 (a) (i) thermal stability decreases down Group VII (1)
- (ii) from Cl to I, atomic size increases **or**  
 the bonding pair is further from the nucleus of X **or**  
 H—X bond becomes longer **or**  
 smaller orbital overlap occurs (1)  
 hence H—X bond strength decreases down Group VII (1) [3]

(b)  $K_c = \frac{[\text{HI}]^2}{[\text{H}_2] \times [\text{I}_2]}$  (1)

no units – must be clearly stated (1) [2]

- (c) (i) no change (1)  
 $K_c$  has no units **or**  
 same no. of molecules / moles each side of equilibrium (1)
- (ii) equilibrium moves to RHS (1)  
 $K_c$  increases with decreasing temperature **or**  
 forward reaction is exothermic **or**  
 reverse reaction is endothermic (1) [4]

(d)	$\text{H}_2(\text{g})$	+	$\text{I}_2(\text{g})$	$\rightleftharpoons$	$2\text{HI}(\text{g})$	
initial moles	0.02		0.02		0	
equil. moles	$(0.02 - y)$		$(0.02 - y)$		$2y$	(1)
equil. conc/mol dm <sup>-3</sup>	$\frac{(0.02 - y)}{1}$		$\frac{(0.02 - y)}{1}$		$\frac{2y}{1}$	

$$K_c = \frac{\text{HI}^2}{[\text{H}_2] \times [\text{I}_2]} = \frac{(2y)^2}{(0.02 - y)^2} = 59 \quad (1)$$

$$\frac{2y}{(0.02 - y)} = \sqrt{59} = 7.7$$

$$2y = (7.7 \times 0.02) - 7.7y$$

$$9.7y = 0.154$$

$$\text{gives } y = \frac{0.154}{9.7} = 0.0159 = 0.016 \quad (1)$$

**at equilibrium**

$$n(\text{HI}) = 2 \times 0.016 = 0.032 \text{ and} \quad (1)$$

$$n(\text{H}_2) = n(\text{I}_2) = (0.02 - 0.016) = 0.004$$

allow ecf where possible [4]

**[Total: 13]**

Page 4	Mark Scheme	Syllabus	Paper
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- 3 (a) (i)  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$  **or**  
 $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$   
state symbols required (1)
- (ii) **pressure** between 60 and 250 atm **or**  
between  $60 \times 10^5$  Pa and  $250 \times 10^5$  Pa (1)
- temperature** between 300 and 550 °C (1)
- catalyst** iron / iron oxide (1)
- (iii) manufacture of  $\text{HNO}_3$  / as a cleaning agent / refrigerant / fertiliser / manufacture of fertilisers / explosives / to remove  $\text{SO}_2$  from combustion products of hydrocarbon fuels (1) [5]
- (b) (i)  $\text{NH}_4\text{Cl}$  and  $\text{Ca}(\text{OH})_2$   
**both formulae** required (1)
- (ii)  $2\text{NH}_4\text{Cl} + \text{Ca}(\text{OH})_2 \rightarrow \text{CaCl}_2 + 2\text{NH}_3 + 2\text{H}_2\text{O}$  **or**  
 $\text{NH}_4^+ + \text{OH}^- \rightarrow \text{NH}_3 + \text{H}_2\text{O}$   
correct products (1)  
correctly balanced equation (1)
- (iii)  $\text{CaO}$  (1)  
it is not an acid / it is basic / it does not react with  $\text{NH}_3$  **or**  
**both**  $\text{P}_2\text{O}_5$  /  $\text{P}_4\text{O}_{10}$  **and**  $\text{H}_2\text{SO}_4$  are acidic / react with  $\text{NH}_3$  (1) [5]
- (c)
- $$\begin{array}{c} \text{H} \\ | \\ \text{H}-\text{N}: \\ | \\ \text{H} \end{array} + \text{H}^+ \longrightarrow \left[ \begin{array}{c} \text{H} \\ | \\ \text{H}-\text{N} \rightarrow \text{H} \\ | \\ \text{H} \end{array} \right]^+$$
- correct displayed eqn.,  
with positive charge clearly shown (1)  
lone pair on  $\text{NH}_3$  (1)  
co-ordinate / dative bond clearly shown (1) [3]

[Total: 13]

Page 5	Mark Scheme	Syllabus	Paper
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## 4 (a) (i)

reaction	organic compound	reagent	structural formulae of organic products
A	$(\text{CH}_3)_3\text{COH}$	$\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$ heat under reflux	no reaction
B	$\text{CH}_3\text{CH}_2\text{CHO}$	Fehling's reagent warm	$\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$ or $\text{CH}_3\text{CH}_2\text{CO}_2^-$
C	$\text{HCO}_2\text{CH}(\text{CH}_3)_2$	$\text{NaOH}(\text{aq})$ warm	$\text{HCO}_2\text{Na}$ or $\text{HCO}_2^-$ $(\text{CH}_3)_2\text{CHOH}$
D	$\text{CH}_2=\text{CHCHO}$	$\text{NaBH}_4$	$\text{CH}_2=\text{CHCH}_2\text{OH}$
E	$(\text{CH}_3)_3\text{COH}$	$\text{NaBH}_4$	no reaction
F	$\text{CH}_3\text{CH}_2\text{COCH}_3$	$\text{MnO}_4^-/\text{H}^+$ heat under reflux	no reaction

each correct answer gets (1)

(7 × 1)

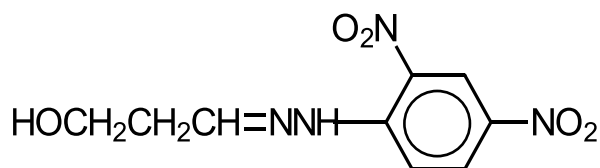
## (ii)

reaction	colour at the beginning of the reaction	colour at the end of the reaction
B	blue	brick red

each correct answer gets 1

(1 + 1 + 1) [10]

## (b) (i)



(1)

(ii) red or orange

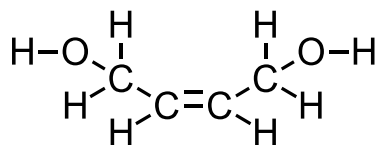
(1) [2]

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Page 6	Mark Scheme	Syllabus	Paper
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- 5 (a) (i) carboxylic acid **or** alcohol present **or** carboxylic acid **and** alcohol present **not** acid **or** carboxyl **or** hydroxyl (1)
- (ii) carboxylic acid **not** present **or** only alcohol present (1)
- (iii) alkene **or**  $>C=C<$  present (1) [3]

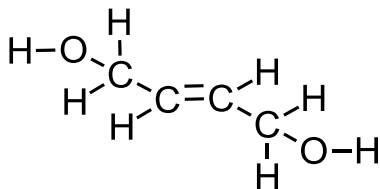
(b) (i)



each correct structure gets (1)

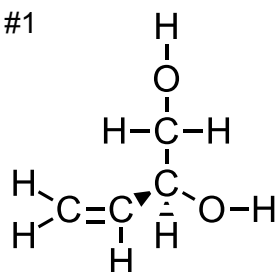
(4 × 1)

(ii) pair 1 geometrical **or** *cis-trans* **or** *E/Z* isomerism (1)

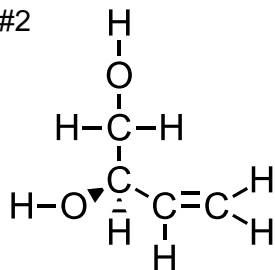


pair 2 optical isomerism – accept chiral compounds (1) [6]

#1



#2



[Total: 9]