

**CAMBRIDGE INTERNATIONAL EXAMINATIONS**

**GCE Advanced Level**

## **MARK SCHEME for the May/June 2013 series**

### **9701 CHEMISTRY**

**9701/41**

Paper 4 (A2 Structured Questions), maximum raw mark 100

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.

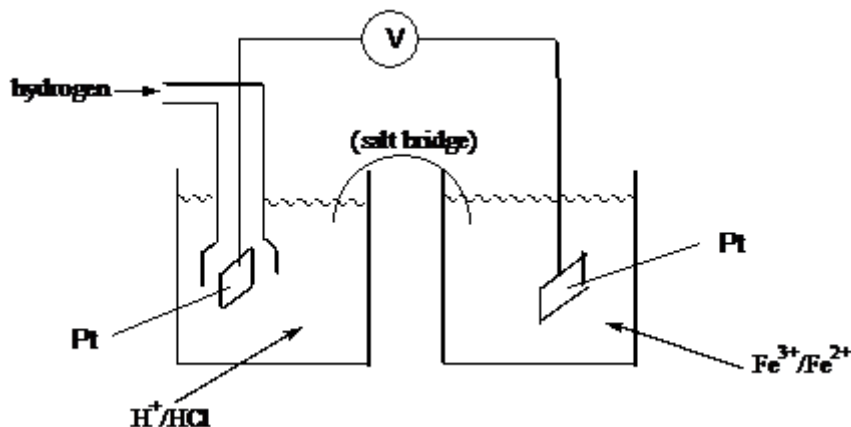
Cambridge will not enter into discussions about these mark schemes.

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- 1 (a) The potential of an **electrode** compared to that of a standard hydrogen electrode (SHE)  
*or*  
 the EMF of a **cell** composed of the test electrode and the SHE [1]  
 all measurement concentrations of 1 mol dm<sup>-3</sup> **and** 298 K/1 atm pressure [1]  
 [2]

(b)



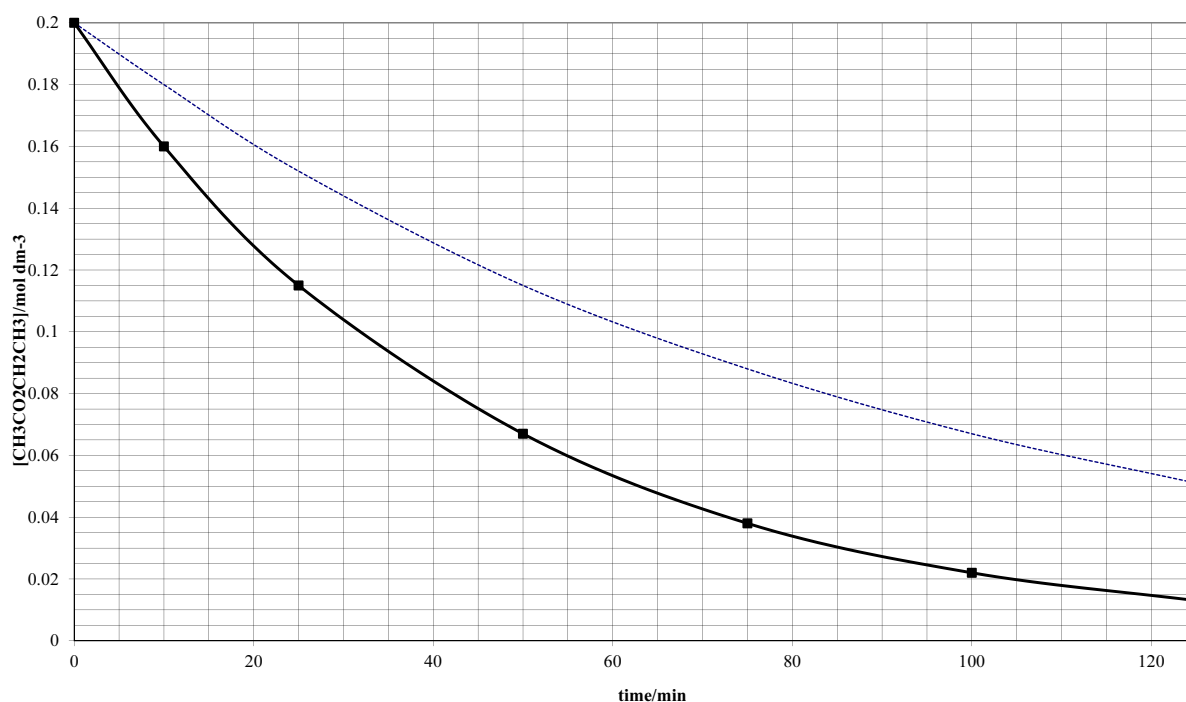
- H<sub>2</sub> and good delivery system [1]  
 Fe<sup>2+</sup>/Fe<sup>3+</sup> solution labelled [1]  
 platinum electrodes (both) [1]  
 salt bridge and voltmeter [1]  
 H<sup>+</sup> or HCl or H<sub>2</sub>SO<sub>4</sub> [1]  
*(acid is not sufficient)*  
 [5]

- (c) (i)  $E^{\ominus} = 0.77 - 0.54 = 0.23$  (V) [1]  
 (ii) Since  $E^{\ominus}$  is positive/  $E^{\ominus} > 0$   
 So more products / the equilibrium will be over to the right / forward reaction is favoured  
 ecf from (c)(i) [1]  
 (iii)  $K_c = [\text{Fe}^{2+}]^2[\text{I}_2] / [\text{Fe}^{3+}]^2[\text{I}^-]^2$  [1]  
 units are mol<sup>-1</sup> dm<sup>3</sup> ecf on expression [1]  
 (iv) ([Fe<sup>2+</sup>] must always be twice [I<sub>2</sub>], so) [Fe<sup>2+</sup>] = 0.02 (mol dm<sup>-3</sup>) [1]  
 ([I<sup>-</sup>] must always be equal to [Fe<sup>3+</sup>], so) [I<sup>-</sup>] = 2 × 10<sup>-4</sup> (mol dm<sup>-3</sup>) [1]  
 (v)  $K_c = \{(0.02)^2 \times 0.01\} / \{(2 \times 10^{-4})^2 \times (2 \times 10^{-4})^2\}$  correct expression [1]  
 (allow ecf from incorrect expression in (c)(iii))  
 (allow ecf from (c)(iv))  
 = (4 × 10<sup>-6</sup>) / (1.6 × 10<sup>-1.5</sup>) = 2.5 × 10<sup>9</sup> (mol<sup>-1</sup> dm<sup>3</sup>) [1]  
 [8]

[Total: 15]

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## 2 (a) (i)



plotting of points (–1 for any error – plotted to within ½ square) [1]  
a good best fit curve [1]

- (ii) construction lines for two half-lives **and**  $t_{1/2} \approx 63$  m or 32 m ( $\pm 3$  min) /  $t_{1/2}$  is constant  
*or*  
construction lines for two tangents **and** mention of two values / concentration doubled, rate doubled [1]
- (iii) *either* ratio of (initial) rates (slopes) *or* ratio of  $t_{1/2} = 2.0$  [1]  
so reaction is first order w.r.t. [HCl] [1]
- (iv) rate =  $k[\text{CH}_3\text{CO}_2\text{CH}_2\text{CH}_3][\text{HCl}]$  conditional on (a)(iii) **and** ecf from (a)(iii) [1]  
(initial) rate = 0.2/95 *or* 0.2/47  
 $\approx 2.1 \times 10^{-3}$  *or*  $4.3 \times 10^{-3}$  (mol dm<sup>-3</sup> min<sup>-1</sup>) [1]  
 $k = 2.1 \times 10^{-3} / (0.2 \times 0.1)$  *or*  $4.3 \times 10^{-3} / (0.2 \times 0.2)$   
 $\approx 0.11$  (mol<sup>-1</sup> dm<sup>3</sup> min<sup>-1</sup>) [1]  
**[8 max 7]**

- (b) (i) because H<sub>2</sub>O is the solvent *or* its concentration cannot change [1]  
(ii) because HCl is a catalyst [1]  
**[2]**

**[Total: 9]**

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3 (a) (i) density = mass per unit volume [1]

(ii) mass per atom or  $A_r$  is larger (for Fe)  
Or  
Fe 55.8 and Ca 40.1 [1]

Fe radii/volume of atom/ion is smaller  
or  
 $R_{Fe} = 0.116$  nm whereas  $R_{Ca} = 0.197$  nm [1]  
[3]

(b)

reaction	acid-base	ligand exchange	precipitation	redox
$[Cu(H_2O)_6]^{2+} + 4NH_3 \rightarrow [Cu(NH_3)_4]^{2+} + 6H_2O$		✓		
$[Cu(H_2O)_6]^{2+} + 4HCl \rightarrow [CuCl_4]^{2-} + 4H^+ + 6H_2O$		✓		
$2FeCl_2 + Cl_2 \rightarrow 2FeCl_3$				✓
$[Fe(H_2O)_6]^{2+} + 2OH^- \rightarrow Fe(OH)_2 + 6H_2O$	✓		✓	
$2Fe(OH)_2 + \frac{1}{2}O_2 + H_2O \rightarrow 2Fe(OH)_3$				✓
$CrO_3 + 2HCl \rightarrow CrO_2Cl_2 + H_2O$	✓	✓		
$Cr(H_2O)_3(OH)_3 + OH^- \rightarrow [Cr(H_2O)_2(OH)_4]^- + H_2O$	✓	✓		
$[Cr(OH)_4]^- + \frac{1}{2}H_2O_2 + OH^- \rightarrow CrO_4^{2-} + 4H_2O$		✓		✓

(Where more than one tick appears on a line in the table above – these are alternatives – but allow the mark if both are given).

[8]

(c)  $n(H_2) = 8/24 = 0.33$  mol [1]

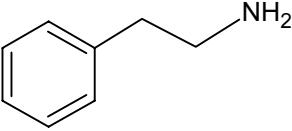
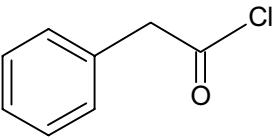
from equation, this is produced from 0.22 mol of Al ecf ( $\times 2/3$ ) [1]

$A_r(Al) = 27$  thus mass of Al =  $27 \times 0.22 = 5.9 - 6$  g hence 5.9–6.0% ecf ( $\times 27$ ) [1]

[3]

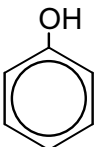
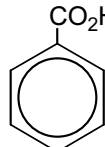
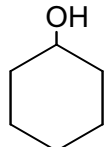
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- 4 (a) (due to the) strong  $\text{N}\equiv\text{N}$  bond [1]  
[1]
- (b) (i) Any balanced equation forming a stable nitrogen oxide  
e.g.  $\text{N}_2 + \text{O}_2 \longrightarrow 2\text{NO}$   
or  
 $\text{N}_2 + 2\text{O}_2 \longrightarrow 2\text{NO}_2$  [1]
- (ii) in lightning [1]  
in an engine/combustion of fuels (or a specific example) [1]
- (iii) ( $\text{NO}_x$  produces) acid rain or forms (photochemical) smog [1]  
[4]
- (c) (base is a) proton acceptor [1]  
basicities: ethylamine >  $\text{NH}_3$  > phenylamine [1]  
ethylamine (more basic) due to electron donating ethyl group [1]  
phenylamine (less basic) due to lone pair being delocalised into the ring [1]  
[4]
- (d) (i) step 1: nucleophilic substitution [1]  
step 2: hydrolysis [1]
- (ii) step 1: KCN (in ethanol) **and** reflux [1]  
step 2:  $\text{H}_3\text{O}^+$  / aqueous acid **and** reflux [1]
- (iii) T is  
 [1]
- W is  
 [1]  
[6]
- [Total: 15]

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5 (a)

	H <sub>2</sub> O			
Na	H <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub>
KOH(aq)	X	X	X	X
Na <sub>2</sub> CO <sub>3</sub> (aq)	X	X	CO <sub>2</sub>	X

[5]

(b) (i) (CH<sub>3</sub>)<sub>3</sub>C-Cl (any unambiguous structure or name) [1]

(ii) reduction or hydrogenation [1]

(iii) either CH<sub>3</sub>CO<sub>2</sub>H and heat with (conc) H<sub>2</sub>SO<sub>4</sub>  
or  
CH<sub>3</sub>COCl [1]

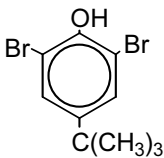
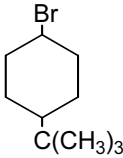
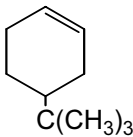
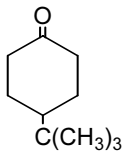
(iv) reflux [1]

dilute HCl [1]

[5]

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(c) (i)

reagent and conditions	product with A	product with B
$\text{Br}_2(\text{aq})$		no reaction
heat with HBr	no reaction	
pass vapour over heated $\text{Al}_2\text{O}_3$	no reaction	
heat with acidified $\text{K}_2\text{Cr}_2\text{O}_7$	no reaction	

[6]

(ii) *either:*  $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$ : no observation with **A** and goes from orange to green with **B**.*or:* $\text{Br}_2(\text{aq})$ : white ppt. with **A** and no observation/ppt with **B**

[1]

[7]

[Total: 17]

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6 (a)

substance	protein synthesis	formation of DNA
adenine		✓
alanine	✓	
aspartate	✓	
phosphate		✓

[3]

[3]

(b) protein : hydrogen bonds

[1]

between –NH and C=O groups on different (peptide) groups

[1]

DNA : hydrogen bonds

[1]

between bases / A &amp; T / C &amp; G on different chains

[1]

[4]

(c) primary: covalent bonds between (successive) amino acids

[1]

tertiary :

hydrogen bonds	between –COOH / –OH and –NH <sub>2</sub> (in side chains)
ionic bonds	between –NH <sub>3</sub> <sup>+</sup> and –CO <sub>2</sub> <sup>-</sup> (in side chains)
disulfide bonds	between cysteine molecules / residues / –SH groups (in side chains)
van der Waals/VDW forces	between alkyl groups / non-polar residues (in side chains)

any two rows

[2]

[3]

[Total: 10]



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7 (a) Any four from:

- extract DNA
- use restriction enzymes (to break DNA into fragments)
- use polymerase chain reaction (to increase concentration of fragments)
- place samples on (agarose) gel
- carry out electrophoresis
- label fragments (transferred to a membrane) with radioactive isotope

[4 × 1]  
[4]

(b)

item for testing	suitable for DNA fingerprinting
human hair	✓
piece of a flint tool	x
piece of Iron Age pot	x
piece of Roman leather	✓

[3]  
[3]

(c) insecticides: gas-liquid *or* thin-layer chromatography

[1]

dyes : paper *or* thin-layer chromatography

[1]

drugs: gas-liquid  
*or*  
thin-layer chromatography

[1]  
[3]

[Total: 10]

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8 (a) (i)



[1]

(ii) Addition [1]

(iii) Hydrogen bonding [1]  
[3]

(b) (i) more / increase water absorbing properties (allow attracts water more) [1]

more polar(ity)/more hydrophilic / has ionic side-chains (as well as hydrophilic ones) [1]

(ii) It should be biodegradable/decompose [1]  
[3]

(c) idea of ion exchange / replacement of  $\text{Na}^+$  for  $\text{Cd}^{2+}/\text{Pb}^{2+}$  [1]

(the metal ions) will be attracted to the carboxylate ions [1]  
[2]

(d) (i) condensation [1]

(ii) OH/alcohol groups [1]  
so highly soluble / able to form hydrogen bonds [2]

[Total: 10]