

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

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

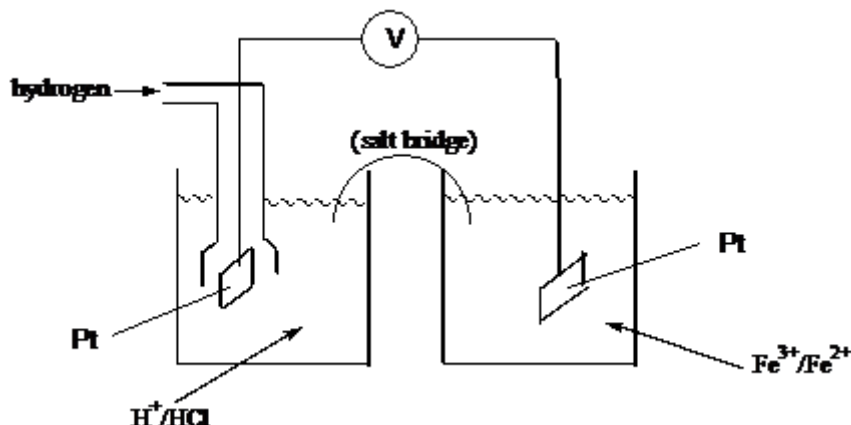
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| Page 2 | Mark Scheme | Syllabus | Paper |
|--------|-----------------------------|----------|-------|
| | GCE A LEVEL – May/June 2013 | 9701 | 41 |

- 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⁻³ **and** 298 K / 1 atm pressure [1]
[2]

(b)



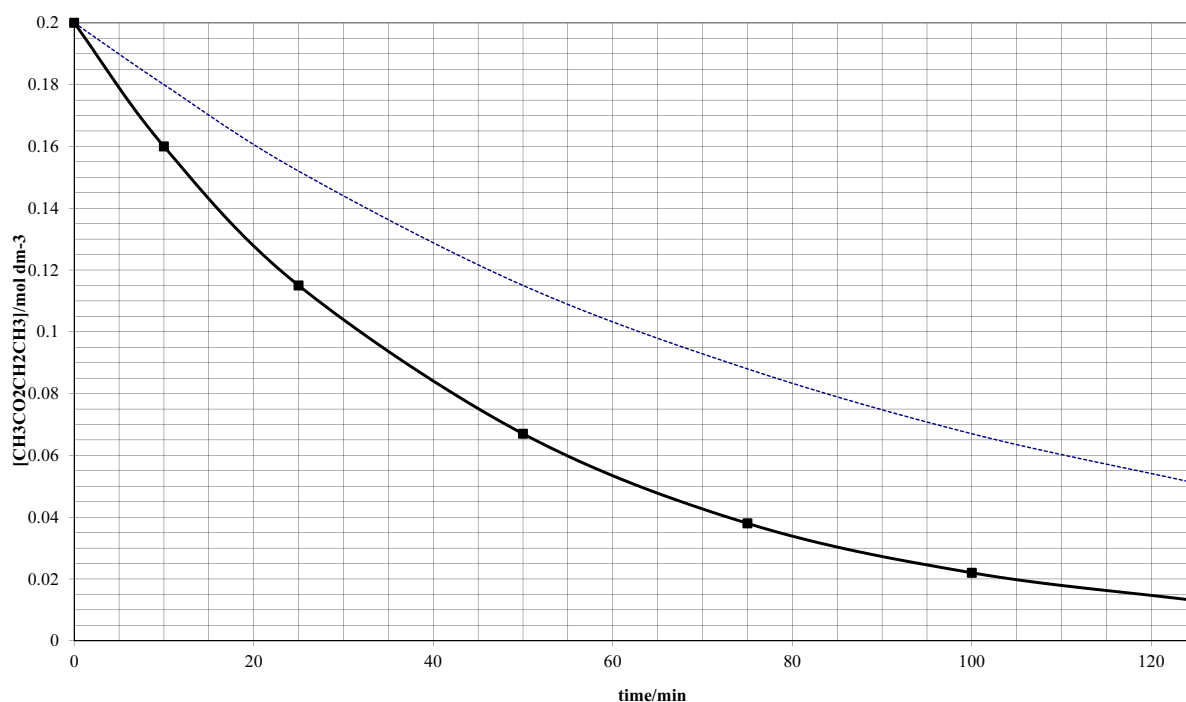
- H₂ and good delivery system [1]
Fe²⁺/Fe³⁺ solution labelled [1]
platinum electrodes (both) [1]
salt bridge and voltmeter [1]
H⁺ or HCl or H₂SO₄ [1]
(acid is not sufficient) [5]

- (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⁻¹ dm³ ecf on expression [1]
(iv) ([Fe²⁺] must always be twice [I₂], so) [Fe²⁺] = 0.02 (mol dm⁻³) [1]
([I⁻] must always be equal to [Fe³⁺], so) [I⁻] = 2 × 10⁻⁴ (mol dm⁻³) [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 × 10⁻⁶) / (1.6 × 10⁻¹⁵) = 2.5 × 10⁹ (mol⁻¹ dm³) [1]
[8]

[Total: 15]

| | | | |
|--------|-----------------------------|----------|-------|
| Page 3 | Mark Scheme | Syllabus | Paper |
| | GCE A LEVEL – May/June 2013 | 9701 | 41 |

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 (± 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* 4.3×10^{-3} (mol dm³ min⁻¹) [1]
 $k = 2.1 \times 10^{-3} / (0.2 \times 0.1)$ *or* $4.3 \times 10^{-3} / (0.2 \times 0.2)$
 ≈ 0.11 (mol⁻¹ dm³ min⁻¹) [1]
[8 max 7]

- (b) (i) because H₂O is the solvent *or* its concentration cannot change [1]
(ii) because HCl is a catalyst [1]
[2]

[Total: 9]

| | | | |
|---------------|------------------------------------|-----------------|--------------|
| Page 4 | Mark Scheme | Syllabus | Paper |
| | GCE A LEVEL – May/June 2013 | 9701 | 41 |

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
 $R_{Fe} = 0.116 \text{ nm}$ whereas $R_{Ca} = 0.197 \text{ nm}$ [1]
[3]

(b)

| reaction | acid-base | ligand exchange | precipitation | redox |
|--|-----------|-----------------|---------------|-------|
| $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 4\text{NH}_3 \rightarrow [\text{Cu}(\text{NH}_3)_4]^{2+} + 6\text{H}_2\text{O}$ | | ✓ | | |
| $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 4\text{HCl} \rightarrow [\text{CuCl}_4]^{2-} + 4\text{H}^+ + 6\text{H}_2\text{O}$ | | ✓ | | |
| $2\text{FeCl}_2 + \text{Cl}_2 \rightarrow 2\text{FeCl}_3$ | | | | ✓ |
| $[\text{Fe}(\text{H}_2\text{O})_6]^{2+} + 2\text{OH}^- \rightarrow \text{Fe}(\text{OH})_2 + 6\text{H}_2\text{O}$ | ✓ | | ✓ | |
| $2\text{Fe}(\text{OH})_2 + \frac{1}{2}\text{O}_2 + \text{H}_2\text{O} \rightarrow 2\text{Fe}(\text{OH})_3$ | | | | ✓ |
| $\text{CrO}_3 + 2\text{HCl} \rightarrow \text{CrO}_2\text{Cl}_2 + \text{H}_2\text{O}$ | ✓ | ✓ | | |
| $\text{Cr}(\text{H}_2\text{O})_3(\text{OH})_3 + \text{OH}^- \rightarrow [\text{Cr}(\text{H}_2\text{O})_2(\text{OH})_4]^- + \text{H}_2\text{O}$ | ✓ | ✓ | | |
| $[\text{Cr}(\text{OH})_4]^- + 1\frac{1}{2}\text{H}_2\text{O}_2 + \text{OH}^- \rightarrow \text{CrO}_4^{2-} + 4\text{H}_2\text{O}$ | | ✓ | | ✓ |

(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) $n(\text{H}_2) = 8/24 = 0.33 \text{ mol}$ [1]

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

$A_r(\text{Al}) = 27$ thus mass of $\text{Al} = 27 \times 0.22 = 5.9 - 6 \text{ g}$ hence 5.9–6.0% ecf ($\times 27$) [1]
[3]

[Total: 14]

| Page 5 | Mark Scheme | Syllabus | Paper |
|--------|-----------------------------|----------|-------|
| | GCE A LEVEL – May/June 2013 | 9701 | 41 |

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) (NO_x produces) acid rain *or* forms (photochemical) smog [1]
[4]

(c) (base is a) proton acceptor [1]

basicities: ethylamine $>$ 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]

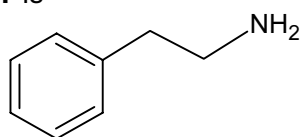
(d) (i) step 1: nucleophilic substitution [1]

step 2: hydrolysis [1]

(ii) step 1: KCN (in ethanol) **and** reflux [1]

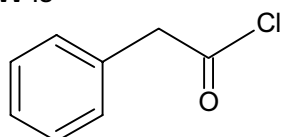
step 2: H_3O^+ / aqueous acid **and** reflux [1]

(iii) T is



[1]

W is



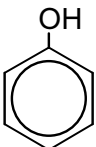
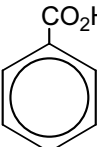
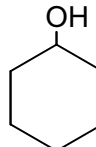
[1]

[6]

[Total: 15]

| | | | |
|--------|-----------------------------|----------|-------|
| Page 6 | Mark Scheme | Syllabus | Paper |
| | GCE A LEVEL – May/June 2013 | 9701 | 41 |

5 (a)

| | | | | |
|--------------------------------------|------------------|---|---|---|
| | H ₂ O |  |  |  |
| Na | H ₂ | H ₂ | H ₂ | H ₂ |
| KOH(aq) | X | X | X | X |
| Na ₂ CO ₃ (aq) | X | X | CO ₂ | X |

[5]

(b) (i) (CH₃)₃C–Cl (any unambiguous structure or name) [1]

(ii) reduction or hydrogenation [1]

(iii) either CH₃CO₂H and heat with (conc) H₂SO₄
or
CH₃COCl [1]

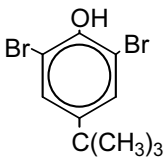
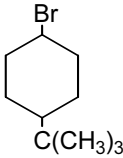
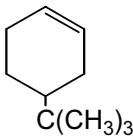
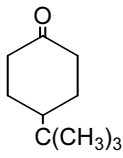
(iv) reflux [1]

dilute HCl [1]

[5]

| | | | |
|--------|-----------------------------|----------|-------|
| Page 7 | Mark Scheme | Syllabus | Paper |
| | GCE A LEVEL – May/June 2013 | 9701 | 41 |

(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 Al_2O_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]

| | | | |
|---------------|------------------------------------|-----------------|--------------|
| Page 8 | Mark Scheme | Syllabus | Paper |
| | GCE A LEVEL – May/June 2013 | 9701 | 41 |

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 & T / C & G on different chains [1]
[4]

(c) primary: covalent bonds between (successive) amino acids [1]

tertiary :

| | |
|--------------------------|--|
| hydrogen bonds | between –COOH / –OH and –NH ₂ (in side chains) |
| ionic bonds | between –NH ₃ ⁺ and –CO ₂ ⁻ (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]

| | | | |
|---------------|------------------------------------|-----------------|--------------|
| Page 9 | Mark Scheme | Syllabus | Paper |
| | GCE A LEVEL – May/June 2013 | 9701 | 41 |

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]

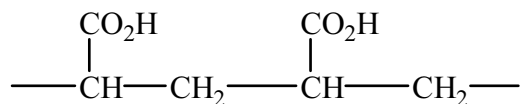
drugs: gas-liquid
or
thin-layer chromatography

[1]
[3]

[Total: 10]

| | | | |
|----------------|------------------------------------|-----------------|--------------|
| Page 10 | Mark Scheme | Syllabus | Paper |
| | GCE A LEVEL – May/June 2013 | 9701 | 41 |

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 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

so highly soluble / able to form hydrogen bonds

[1]

[2]

[Total: 10]