

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.

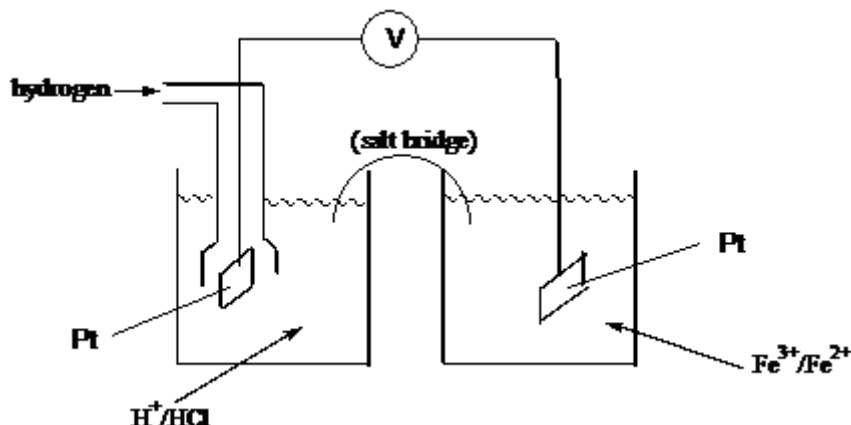
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- 1 (a) The potential of an **electrode** compared to that of a standard hydrogen electrode (SHE)
 or
 the EMF of a **cell** composed of the test electrode and the SHE [1]
 all measurement concentrations of 1 mol dm^{-3} **and** 298 K / 1 atm pressure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

(b)



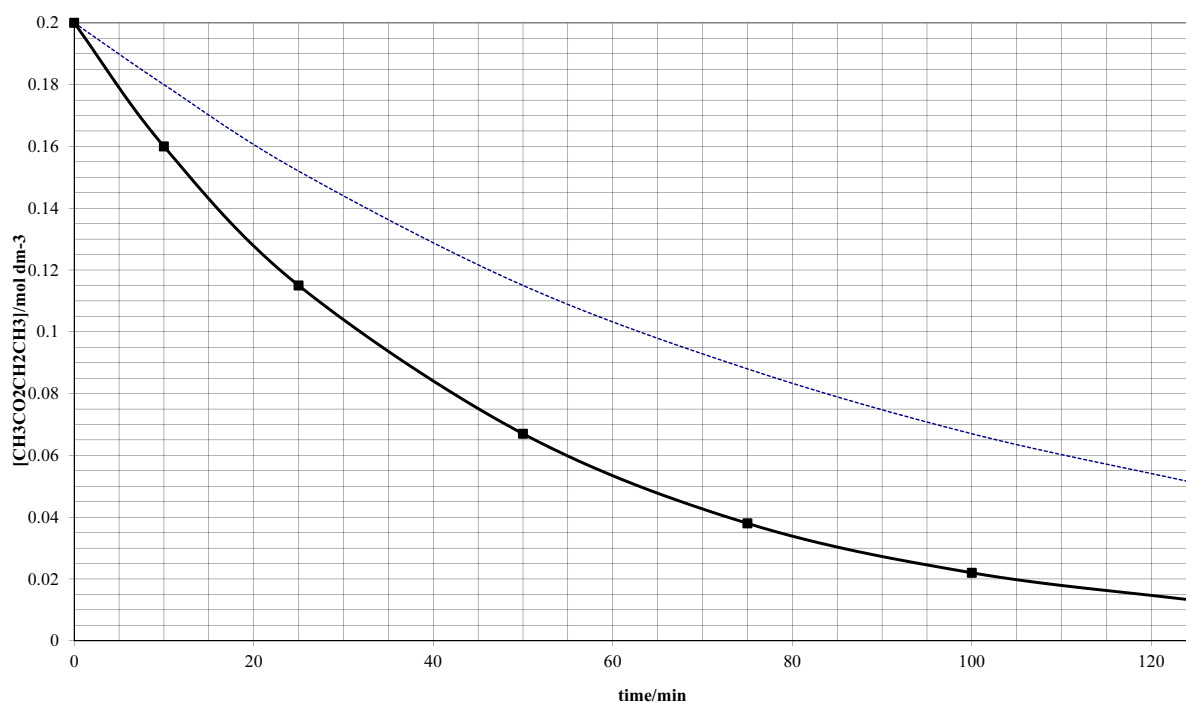
- H₂ and good delivery system [1]
 Fe²⁺/Fe³⁺ solution labelled [1]
 platinum electrodes (both) [1]
 salt bridge and voltmeter [1]
 H⁺ or HCl or H₂SO₄ [1]
 (acid is not sufficient) [5]

- (c) (i) $E^\ominus = 0.77 - 0.54 = 0.23 \text{ (V)}$ [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 $\text{mol}^{-1} \text{ dm}^3$ ecf on expression [1]
 (iv) ($[\text{Fe}^{2+}]$ must always be twice $[\text{I}_2]$, so) $[\text{Fe}^{2+}] = 0.02 \text{ (mol dm}^{-3}\text{)}$ [1]
 ($[\text{I}^-]$ must always be equal to $[\text{Fe}^{3+}]$, so) $[\text{I}^-] = 2 \times 10^{-4} \text{ (mol dm}^{-3}\text{)}$ [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))
 $= (4 \times 10^{-6}) / (1.6 \times 10^{-15}) = 2.5 \times 10^9 \text{ (mol}^{-1} \text{ dm}^3\text{)}$ [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 (± 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 dm⁻³ 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]

| | | | |
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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

$R_{Fe} = 0.116 \text{ nm}$ 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]

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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) (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]

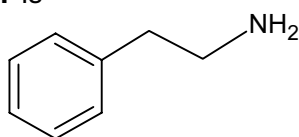
(d) (i) step 1: nucleophilic substitution [1]

step 2: hydrolysis [1]

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

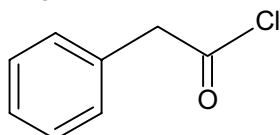
step 2: H_3O^+ / aqueous acid **and** reflux [1]

(iii) T is



[1]

W is



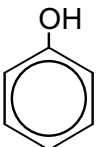
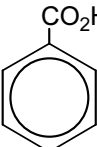
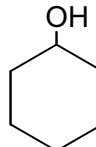
[1]

[6]

[Total: 15]

| | | | |
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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]

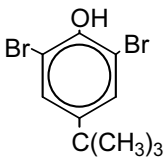
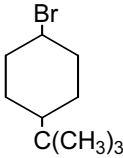
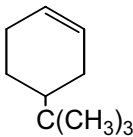
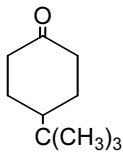
(iv) reflux [1]

dilute HCl [1]

[5]

| | | | |
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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 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]

| | | | |
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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 & 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]

| | | | |
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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]

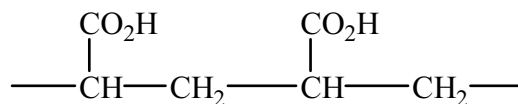
drugs: gas-liquid
or
thin-layer chromatography

[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 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]