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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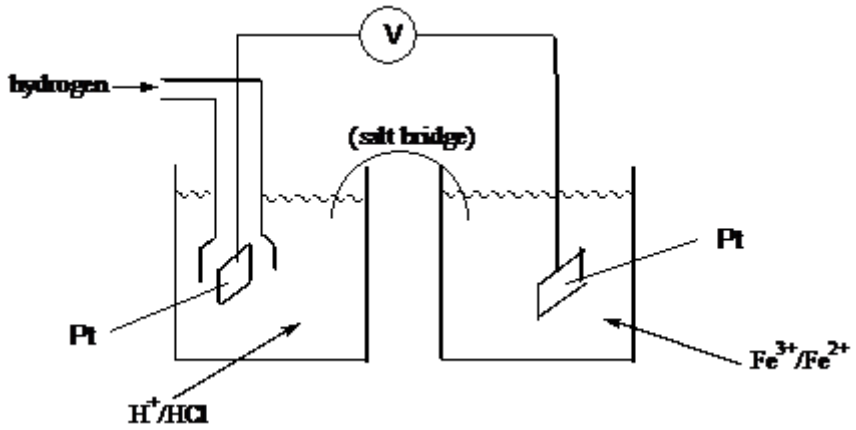
1 (a) The potential of an **electrode** compared to that of a standard hydrogen electrode (SHE)
or
the EMF of a **cell** composed of the test electrode and the SHE [1]

all measurement concentrations of 1 mol dm^{-3} **and** 298 K / 1 atm pressure [1]
[2]

(b)



H_2 and good delivery system [1]
Fe^{2+}/Fe^{3+} solution labelled [1]
platinum electrodes (both) [1]
salt bridge and voltmeter [1]
H^+ *or* HC*l* *or* H_2SO_4 [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) $K_c = [Fe^{2+}]^2[I_2] / [Fe^{3+}]^2[I^-]^2$ [1]

units are **mol^{-1} dm^3** ecf on expression [1]

(iv) ($[Fe^{2+}]$ must always be twice $[I_2]$, so) $[Fe^{2+}] = 0.02$ (mol dm^{-3}) [1]

($[I^-]$ must always be equal to $[Fe^{3+}]$, so) $[I^-] = 2 \times 10^{-4}$ (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)**)
$= (4 \times 10^{-6}) / (1.6 \times 10^{-1.5}) = 2.5 \times 10^9$ (mol^{-1} dm^3) [1]
[8]

[Total: 15]

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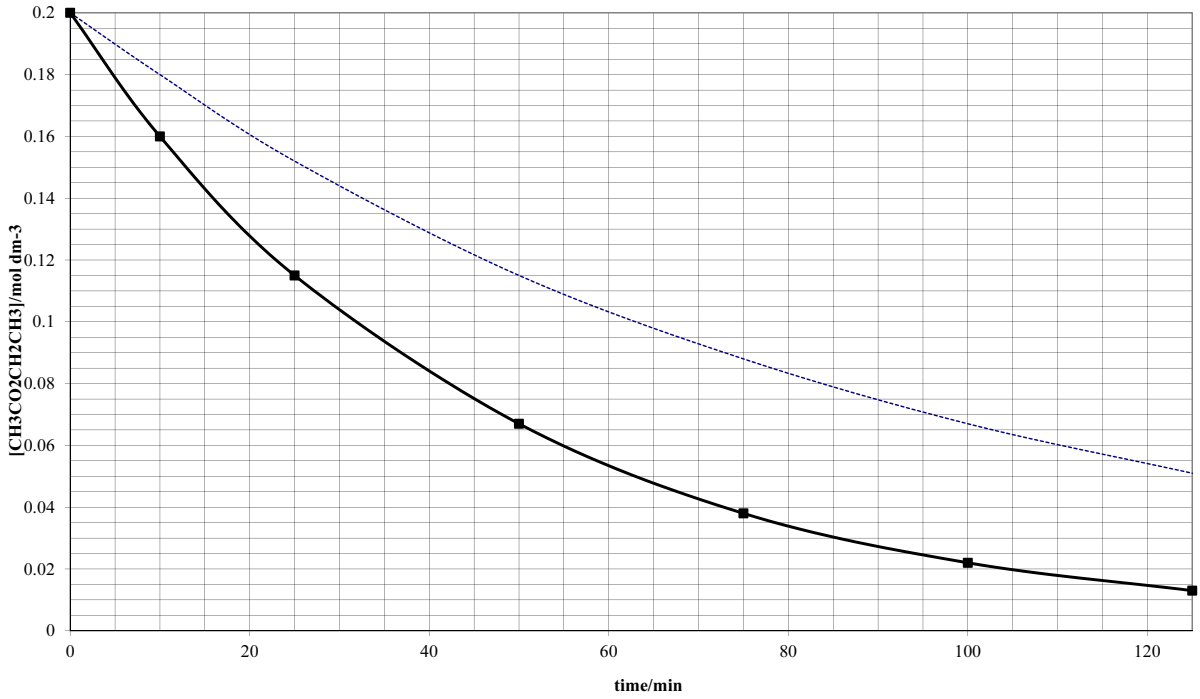
2 (a) (i)



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** $t_{½}$ ≈ 63 m or 32 m (±3 min) / $t_{½}$ 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 $t_{½}$ = 2.0 [1]

so reaction is first order w.r.t. [HC*l*] [1]

(iv) rate = k[$CH_3CO_2CH_2CH_3$][HC*l*] conditional on **(a)(iii) and** ecf from **(a)(iii)** [1]

(initial) rate = 0.2/95 *or* 0.2/47
≈ 2.1×10^{-3} *or* 4.3×10^{-3} (mol dm^{-3} min^{-1}) [1]

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

(b) (i) because H_2O is the solvent *or* its concentration cannot change [1]

(ii) because HC*l* 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
$[Cu(H_2O)_6]^{2+} + 4NH_3 \rightarrow [Cu(NH_3)_4]^{2+} + 6H_2O$		✓		
$[Cu(H_2O)_6]^{2+} + 4HCl \rightarrow [CuCl_4]^{2-} + 4H^+ + 6H_2O$		✓		
$2FeCl_2 + Cl_2 \rightarrow 2FeCl_3$				✓
$[Fe(H_2O)_6]^{2+} + 2OH^- \rightarrow Fe(OH)_2 + 6H_2O$	✓		✓	
$2Fe(OH)_2 + ½O_2 + H_2O \rightarrow 2Fe(OH)_3$				✓
$CrO_3 + 2HCl \rightarrow CrO_2Cl_2 + H_2O$	✓	✓		
$Cr(H_2O)_3(OH)_3 + OH^- \rightarrow [Cr(H_2O)_2(OH)_4]^- + H_2O$	✓	✓		
$[Cr(OH)_4]^- + 1½H_2O_2 + OH^- \rightarrow CrO_4^{2-} + 4H_2O$		✓		✓

(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 (× 2/3) [1]

A_r(Al) = 27 thus mass of Al = 27 × 0.22 = 5.9 – 6 g hence 5.9–6.0% ecf (× 27) [1]
[3]

[Total: 14]

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4 **(a)** (due to the) strong N≡N bond [1]

[1]

(b) **(i)** Any balanced equation forming a stable nitrogen oxide
e.g. $N_2 + O_2 \longrightarrow 2NO$
or
$N_2 + 2O_2 \longrightarrow 2NO_2$ [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]

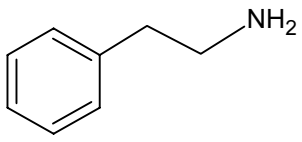
(d) **(i)** step 1: nucleophilic substitution [1]

step 2: hydrolysis [1]

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

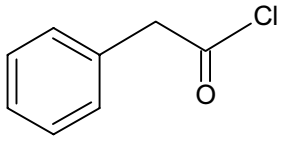
step 2: H_3O^+ / aqueous acid **and** reflux [1]

(iii) **T** is



[1]

W is



[1]

[6]

[Total: 15]

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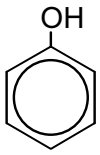
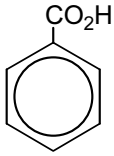
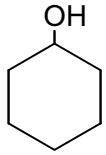
5 (a)

	H_2O			
Na	H_2	**H_2**	**H_2**	**H_2**
KOH(aq)	X	**X**	**X**	**X**
Na_2CO_3(aq)	X	**X**	**CO_2**	**X**

[5]

(b) (i) $(CH_3)_3C–C\mathit{l}$ (any unambiguous structure *or* name) [1]

(ii) reduction *or* hydrogenation [1]

(iii) *either* CH_3CO_2H **and** heat with (conc) H_2SO_4
or
$CH_3COC\mathit{l}$ [1]

(iv) reflux [1]

dilute $HC\mathit{l}$ [1]
[5]

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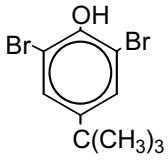
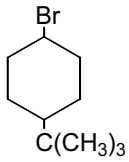
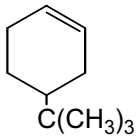
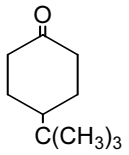
(c) (i)

reagent and conditions	product with **A**	product with **B**
$Br_2(aq)$		no reaction
heat with HBr	no reaction	
pass vapour over heated Al_2O_3	no reaction	
heat with acidified $K_2Cr_2O_7$	no reaction	

[6]

(ii) *either:* $Cr_2O_7^{2-}/H^+$: no observation with **A and** goes from orange to green with **B.**
or:
$Br_2(aq)$: 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	✗
piece of Iron Age pot	✗
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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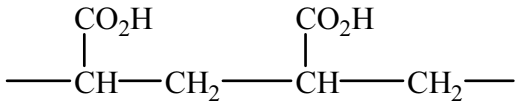
8 (a) (i)



[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 Cd^{2+}/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]

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