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.

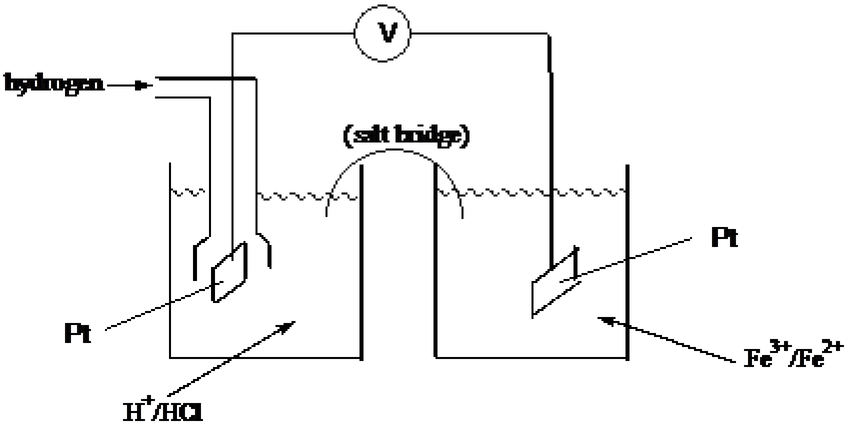
Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

CAMBRIDGE
International Examinations

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* HCl *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]

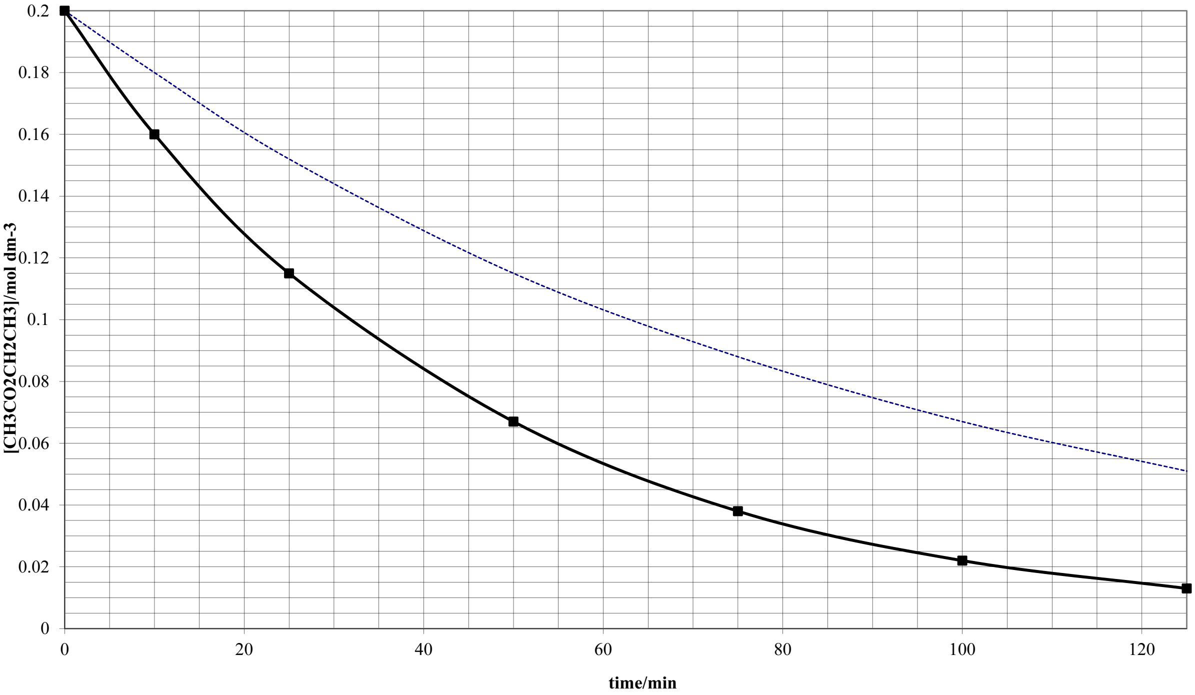
(iv) ($[Fe^{2+}]$ must always be twice $[I_2]$, so) $[Fe^{2+}] = 0.02$ (mol dm^{-3}) [1]

($[I^-]$ 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]

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]

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

(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 A*l* ecf (× 2/3) [1]

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

[Total: 14]

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]

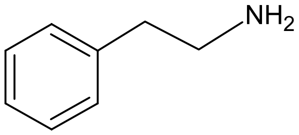
(d) **(i)** step 1: nucleophilic substitution [1]

step 2: hydrolysis [1]

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

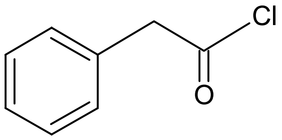
step 2: H_3O^+ / aqueous acid **and** reflux [1]

(iii) **T** is



[1]

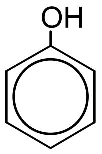
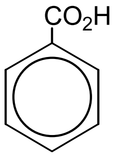
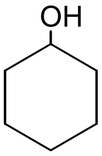
W is



[1]
[6]

[Total: 15]

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) $(CH_3)_3$ C–C*l* (any unambiguous structure *or* name) [1]

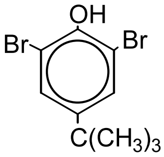
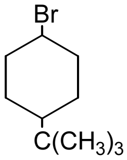
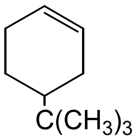
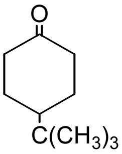
(ii) reduction *or* hydrogenation [1]

(iii) *either* CH_3CO_2H **and** heat with (conc) H_2SO_4
or
CH_3COCl [1]

(iv) reflux [1]

dilute HC*l* [1]
[5]

(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]

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]

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]

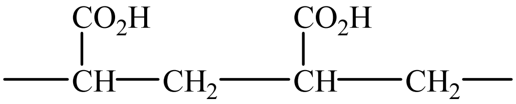
(c) insecticides: gas-liquid *or* thin-layer chromatography [1]

dyes : paper *or* thin-layer chromatography [1]

drugs: gas-liquid
or
thin-layer chromatography [1]
[3]

[Total: 10]

8 **(a)** **(i)**



$$-\overset{\overset{\displaystyle CO_2H}{|}}{CH}-CH_2-\overset{\overset{\displaystyle CO_2H}{|}}{CH}-CH_2-$$

[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]