

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.

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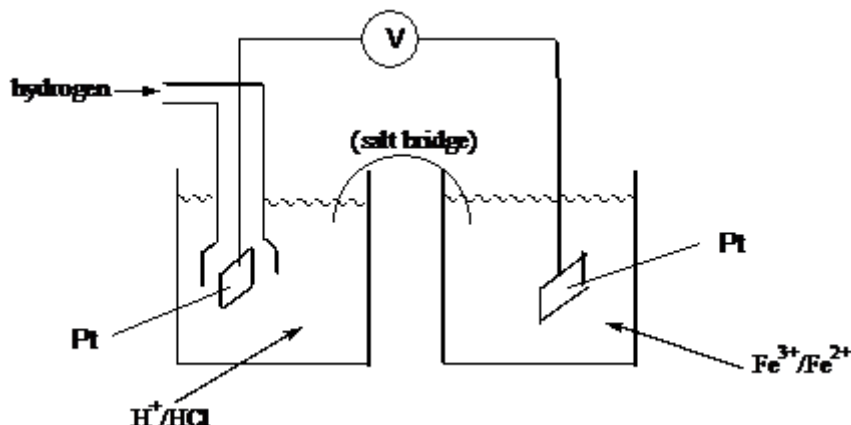
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Page 2	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – May/June 2013	9701	41

- 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)



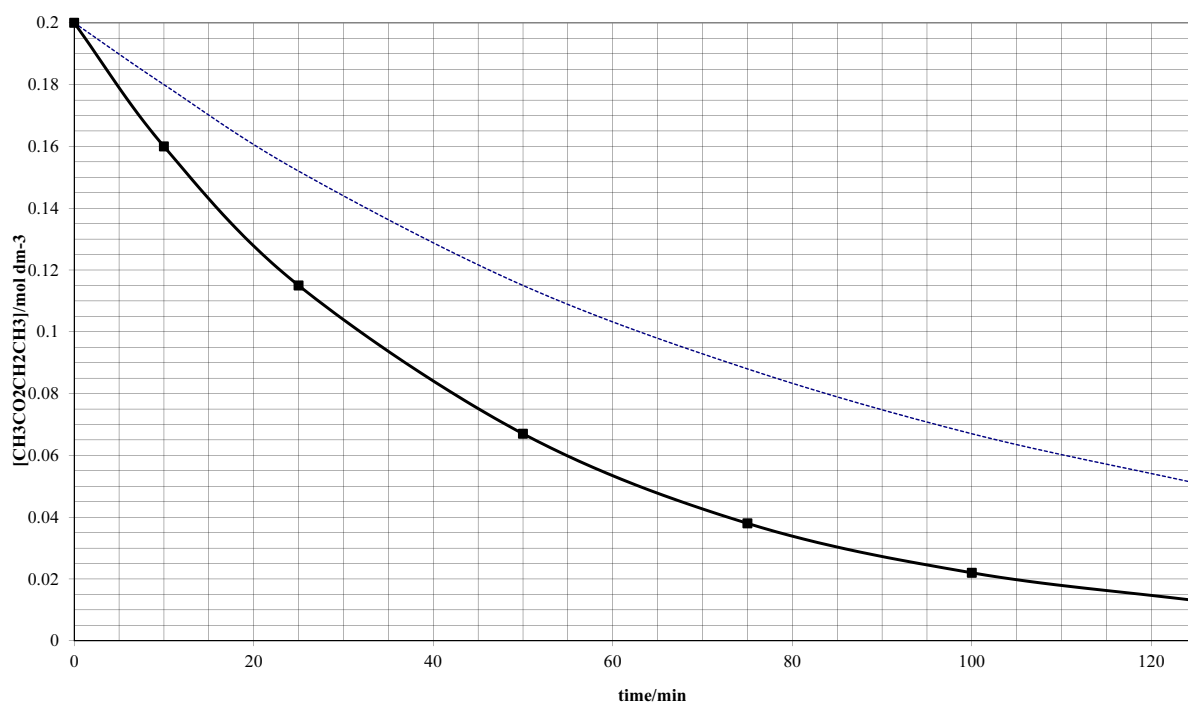
- H₂ and good delivery system [1]
Fe²⁺/Fe³⁺ solution labelled [1]
platinum electrodes (both) [1]
salt bridge and voltmeter [1]
H⁺ or HCl or H₂SO₄ [1]
(acid is not sufficient) [5]

- (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 $\frac{1}{2}$ 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. $[\text{HCl}]$ [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} ($\text{mol dm}^{-3} \text{ min}^{-1}$) [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 ($\text{mol}^{-1} \text{ dm}^3 \text{ min}^{-1}$) [1]
[8 max 7]

- (b) (i) because H_2O 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]

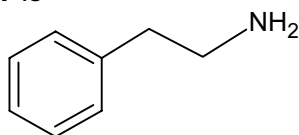
(d) (i) step 1: nucleophilic substitution [1]

step 2: hydrolysis [1]

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

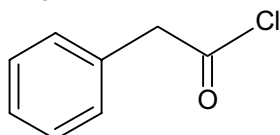
step 2: H_3O^+ / aqueous acid **and** reflux [1]

(iii) T is



[1]

W is



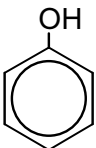
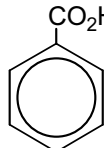
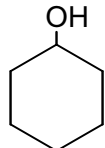
[1]

[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]

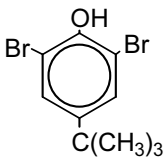
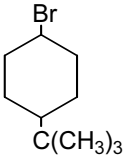
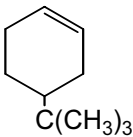
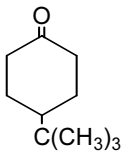
(iv) reflux [1]

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]

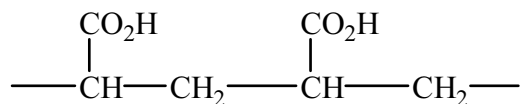
drugs: gas-liquid
or
thin-layer chromatography

[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]

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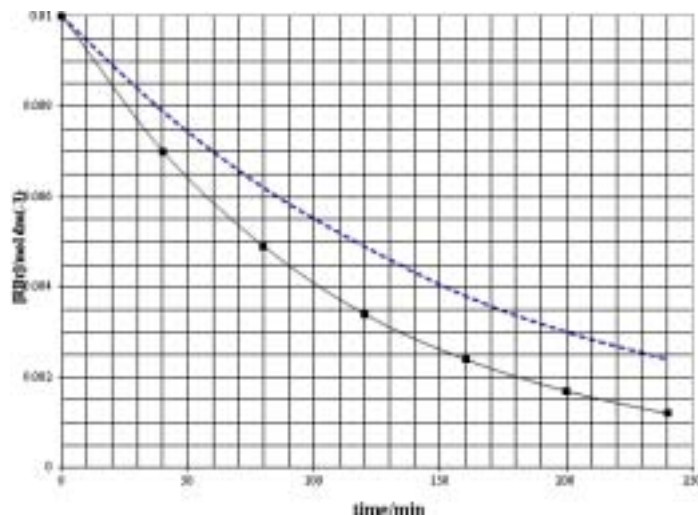
Page 2	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – May/June 2013	9701	42

1 (a) (i) $\text{RBr} + \text{OH}^- \longrightarrow \text{ROH} + \text{Br}^-$ [1]

(ii) nucleophilic substitution [1]

[2]

(b) (i)



plotting of all points (plotted to within $\frac{1}{2}$ small square) [1]

good line of best fit [1]

(ii) $t_{1/2} = 118 \text{ min}$ or $79 \text{ min} (\pm 5 \text{ min})$

or

construction lines for two half-lives **and** mention that half-life is constant

or

calculate the ratio of two rates at two different concentrations

[1]

(iii) either ratio of initial rates (slopes)

or

ratio of $t_{1/2}$

or

ratio of times for $[\text{RBr}]$ to fall to the same level: all should be $= 1.5$

[1]

therefore reaction is first order w.r.t. $[\text{OH}^-]$

[1]

(iv) $\text{rate} = k[\text{RBr}][\text{OH}^-]$

[1]

initial rate $= 0.01 / 185 = 5.4 \times 10^{-5} \text{ (mol dm}^{-3} \text{ min}^{-1}\text{)}$

[1]

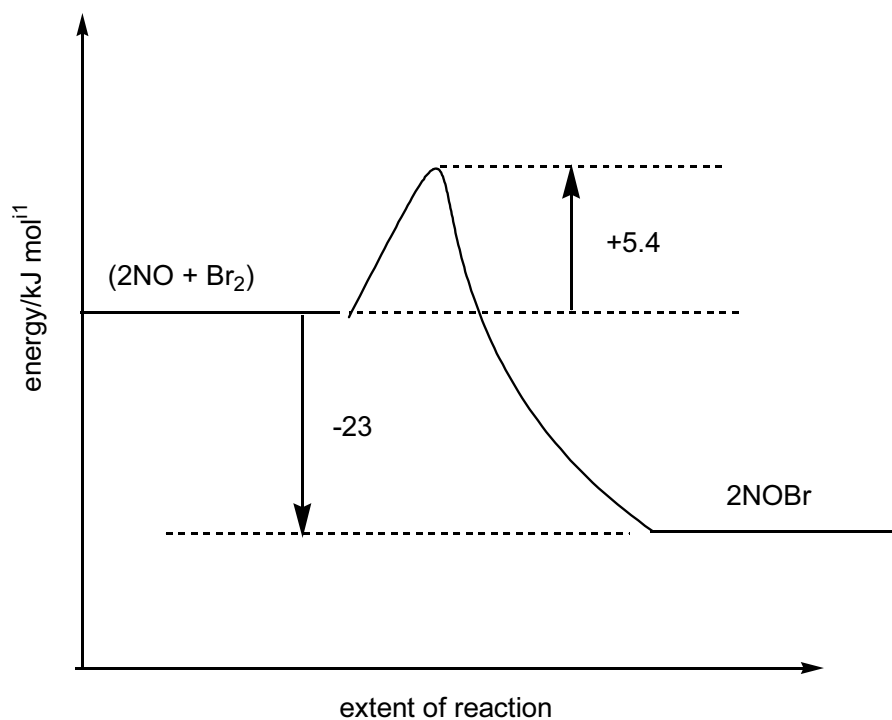
$k = 5.4 \times 10^{-5} / (0.01 \times 0.1) = 0.054 \text{ (mol}^{-1} \text{ dm}^3 \text{ min}^{-1}\text{)}$

[1]

[8 max 7]

Page 3	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – May/June 2013	9701	42

(c)



four marking points: one activation "hump"

2NOBr (not just NOBr)

ΔH labelled correctly (arrow down, or double headed, or just a line)

E_a labelled correctly (arrow up, or double headed, or just a line)

all four points [2]

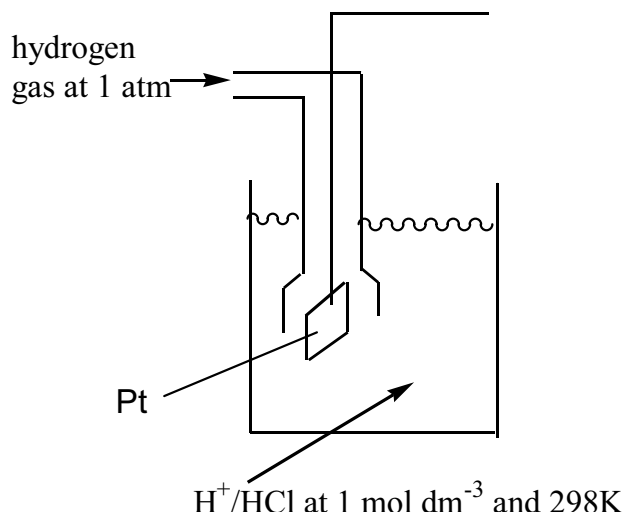
three or two points [1]

[2]

[Total: 11]

Page 4	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – May/June 2013	9701	42

2 (a) (i)



$\text{H}_2(\text{g})$ going in (i.e. not being produced) [1]
 platinum electrode in contact with solution, with H_2 bubbling over it [1]
 H^+ or HCl or H_2SO_4 [1]
 solution at 1 mol dm^{-3} (or 0.5 M if H_2SO_4) and $T=298 \text{ K}$, $p=1 \text{ atm}$ [1]

(ii) $E^\circ = 1.33 - (-0.41) = 1.74 \text{ V}$ [1]



(iii) Colour would change from orange [1]
 to green [1]
[8]

(b) there are two ways of calculating the ratio:
 $\text{pK}_a = -\log_{10}(\text{K}_a) = -\log_{10}(1.79 \times 10^{-5}) = 4.747$ (4.75) or $[\text{H}^+] = 10^{-5.5} = 3.16 \times 10^{-6}$ [1]

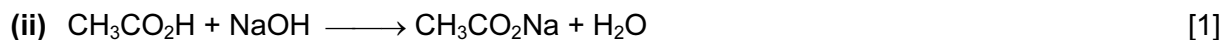
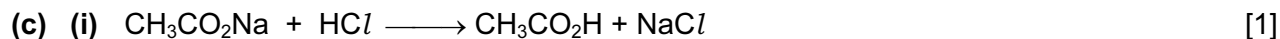
$$\log_{10}([\text{B}] / [\text{A}]) = \text{pH} - \text{pK}_a = 0.753$$
 (0.75) or $[\text{salt}] / [\text{acid}] = \text{K}_a / [\text{H}^+]$ [1]

$$\therefore [\text{B}] / [\text{A}] = 10^{0.753} = 5.66$$

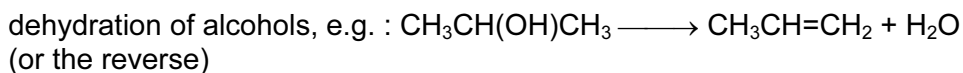
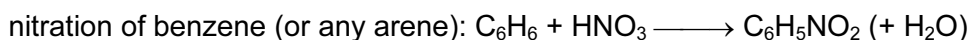
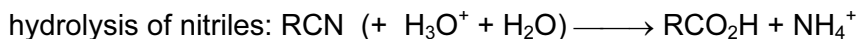
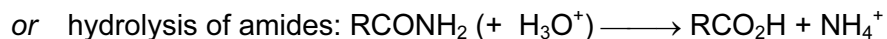
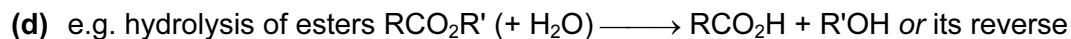
 or $= 1.79 \times 10^{-5} / 3.16 \times 10^{-6} = 5.66$
 (or $[\text{A}] / [\text{B}] = 0.177$) [1]
 (correct ratio = [3] marks)

since $\text{B} + \text{A} = 100$, $\therefore (100 - \text{A}) / \text{A} = 5.66 \Rightarrow$ $\frac{\text{vol of acid} = 15 \text{ cm}^3}{\text{vol of salt} = 85 \text{ cm}^3}$ [1]
[4]

Page 5	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – May/June 2013	9701	42



[2]



[3]

[Total: 17]



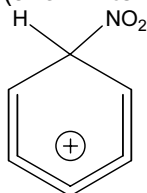
conc (both acids) **and** $30^\circ\text{C} < T < 60^\circ\text{C}$ or warm [1]



and room temp. (allow $T \leq 30^\circ\text{C}$) [1]

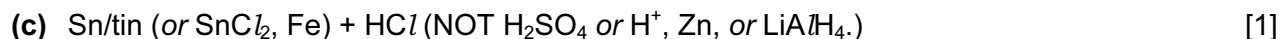
[3]

(b) (allow intermediate from methylbenzene)



[1]

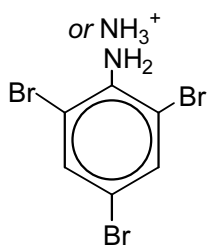
[1]



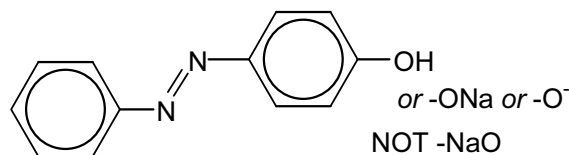
[1]

Page 6	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – May/June 2013	9701	42

(d) (i)



A



B

[1] + [1]

(ii) $\text{NaNO}_2 + \text{HCl}$ or H_2SO_4 or H^+ or HNO_2

[1]

$T \leq 10^\circ\text{C}$

[1]

[4 max 3]

(e) (i) amide

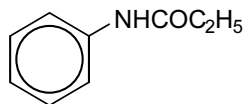
[1]

(ii) $M_r = 108 + 11 + 14 + 16 = 149$

$\%N = (14 \times 100)/149 = 9.4\%$

[1]

(iii)



[1]

[3]

[Total: 11]

4. (a) (i) Many electrons of similar energy in a valence-shell orbital

or

successive ionisation energies rise steadily (no big jumps)

or

ability to form bonds with ligands can stabilise very low or very high oxidation states

or

4s + 3d orbitals/shells/energy levels have similar / same energies

[1]

(ii) VO_2^+ : +5

CrF_6^{2-} : +4

MnO_4^{2-} : +6

[3 × 1]

[4]

Page 7	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – May/June 2013	9701	42

(b)

- (colour due to) absorption of light/photons/frequencies/wavelengths
or
colour seen is complement of colour absorbed.
- d-orbitals/d-subshell split (by ligand field)
- (when photon is absorbed), electron is promoted *or* moves (from lower) to higher (d–)orbital
- energy difference/gap *or* ΔE *or* splitting corresponds to photon/frequency/wavelength in visible region
- in s-block elements the energy gap is too large (to be able to absorb visible light)

[any four 4 × 1]

[4]

(c) (i) $2\text{MnO}_4^- + 2\text{H}_2\text{O} + 5\text{SO}_2 \longrightarrow 2\text{Mn}^{2+} + 5\text{SO}_4^{2-} + 4\text{H}^+$ [1]

(ii) solution will go from purple [1]

to colourless [1]

[3]

(d) (pale) blue solution [1]

gives a (pale) blue ppt. [1]

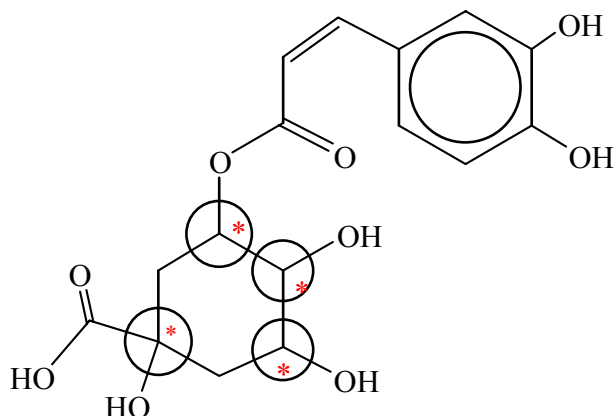
which re-dissolves, *or* forms a solution, which is dark/deep blue *or* purple [1]

[3]

[Total: 14]

Page 8	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – May/June 2013	9701	42

5 (a) (i)



two or three centres correctly identified [1]
four centres correctly identified [2]

(ii) $C_{16}H_{18}O_9$ [1]

(iii) 3 moles of H_2 [1]

(iv) in cold: 3 moles of NaOH [1]

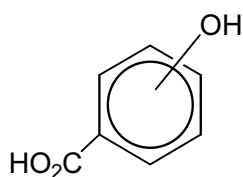
on heating: 4 moles of NaOH [1]
[6]

(b) (i) hydrolysis [1]

(ii) alkene or $C=C$ [1]

(iii) with $Na_2CO_3(aq)$: carboxylic acid [1]
with $Br_2(aq)$: phenol [1]

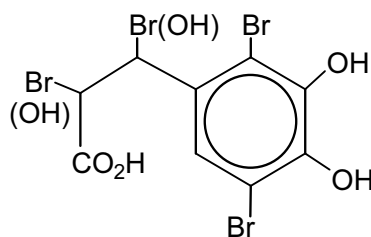
(iv)



F

(OH can be at the 3, 4, or 5 positions, but not the 2 or 6 positions)

[1]



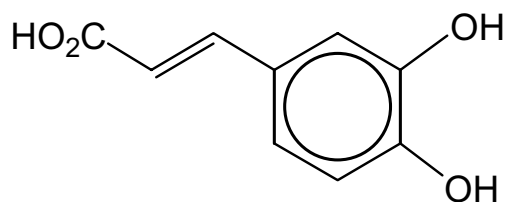
G (ring subst. allow 2 or 3 Br in ring) [1]

(addition to $C=C$: allow one of the aliphatic Br to be OH, but not both) [1]

(v) geometrical or cis-trans or E-Z [1]

Page 9	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – May/June 2013	9701	42

(vi)



skeletal or structural [1]

[9 max 8]

(c) $M_r(\mathbf{E}) = 180$, so $0.1 \text{ g} = 1/1800 (5.56 \times 10^{-4}) \text{ mol}$ [1]

3 mol NaOH react with 1 mol of **E**, so $n(\text{NaOH}) = 3/1800 = 1/600 \text{ mol} = 1.67 \times 10^{-3} \text{ mol}$ [1]

volume of 0.1M NaOH = $1000/(600 \times 0.1) = 16.7 \text{ cm}^3$ [1]

[3]

[Total: 17]

Page 10	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – May/June 2013	9701	42

6 (a)

substance	protein synthesis	formation of DNA
cysteine	✓	
cytosine		✓
glutamine	✓	
guanine		✓

[3]

[3]

(b) (i) Hydrogen bonding

[1]

Between bases *or* between A,T, C and G (all four needed)

[1]

(ii) Bonds are (relatively) weak *or* easily broken

[1]

This enables strands to separate *or* DNA to unzip/unwind/unravel.

[1]

[4]

(c) changes / mutations in DNA

- by the addition / insertion / deletion / substitution / replacement of a base
- adds / deletes / replaces an amino acid *or* changes the amino acid sequence
- this causes a loss of function *or* changes the shape / tertiary structure of the protein

any three points [3]

[3]

[Total: 10]

Page 11	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – May/June 2013	9701	42

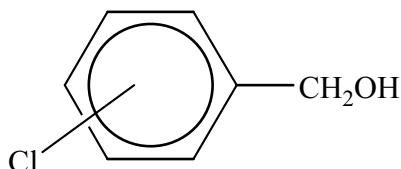
7. (a) (i) $\frac{43.3}{3.35} = \frac{100}{1.1 \times n}$

$n = \frac{100 \times 3.35}{43.3 \times 1.1} = 7.03 = 7$ (calculation must be shown) [1]

(ii) The M and M+2 peaks are in the ratio 3 : 1 hence the halogen is chlorine/Cl [1]

(iii) L contains 7 hydrogen atoms *or* there are 3 types/environments of proton/H [1]

(iv) The multiplet with 4 hydrogens *or* peaks at δ 7.3 suggests a benzene ring
The singlet with 2 hydrogens *or* peak at δ 4.7 suggests a $-\text{CH}_2-$ group
The singlet with 1 hydrogen *or* peak at δ 2.3 suggests an $-\text{OH}$ group
or reaction with Na suggests an OH group
OH must be an alcohol, not a phenol (due to its δ value)
Since L also contains 7 carbon atoms and chlorine, this accounts for 126 of the 142 mass, the remaining atom must be oxygen
Thus L is



(allow the 2-, 3- or 4- isomer)

[6]
[9 max 7]

(b) (i) we expect propene to have a CH_3 peak *or* a peak at m/e 15
or cyclopropane would have fewer peaks

[1]

(ii) cyclopropane would have 1 peak (ignore splitting)
propene would have 2 (*or* 3, *or* 4) peaks (ignore splitting)
or propene would have peaks in the δ 4.5-6.0 (alkene) region
no splitting of cyclopropane peak
(any two points)

[2]
[3]
[Total: 10]

Page 12	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – May/June 2013	9701	42

- 8 (a) (i) $\text{CH}_2 = \text{CH}-\text{CO}_2\text{H}$ or $\text{CH}_2 = \text{CH}-\text{CO}_2\text{R}$ or $\text{CH}_2 = \text{CH}-\text{COCl}$ [2]
- (ii) addition (polymerisation) [1]
- (iii) $\text{C}(\text{CH}_2\text{OH})_4$ [1]
- (iv) water [1]
- [5]
- (b) (water is bonded to the polymer by) hydrogen bonding [1]
hydrogen bonds are weak or easily broken [1]
[2]
- (c) (i) cross-linking causes no reduction in the number of $-\text{OH}$ groups
or cross-linking molecules also have $-\text{OH}$ groups [1]
- (ii) property e.g. becomes harder / more rigid / less flexible / stronger / higher melting point. [1]
because the chains are more strongly / tightly held [1]
[3]
- [Total: 10]

CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the May/June 2013 series

9701 CHEMISTRY

9701/43

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.

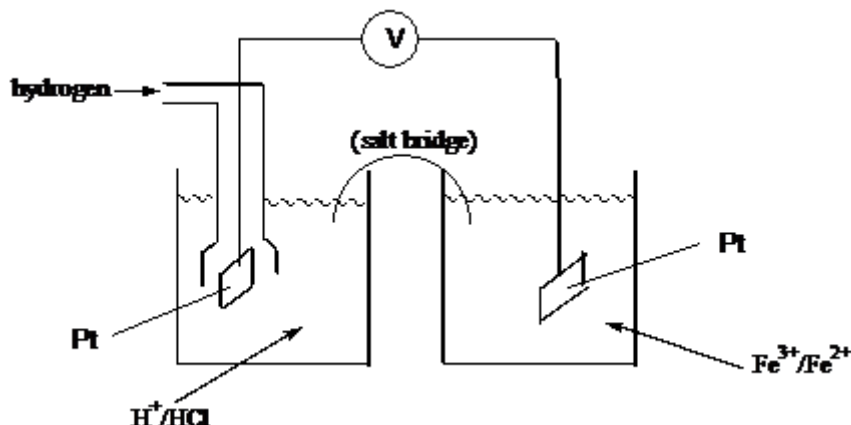
Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2013 series for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level components and some Ordinary Level components.

Page 2	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – May/June 2013	9701	43

- 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)



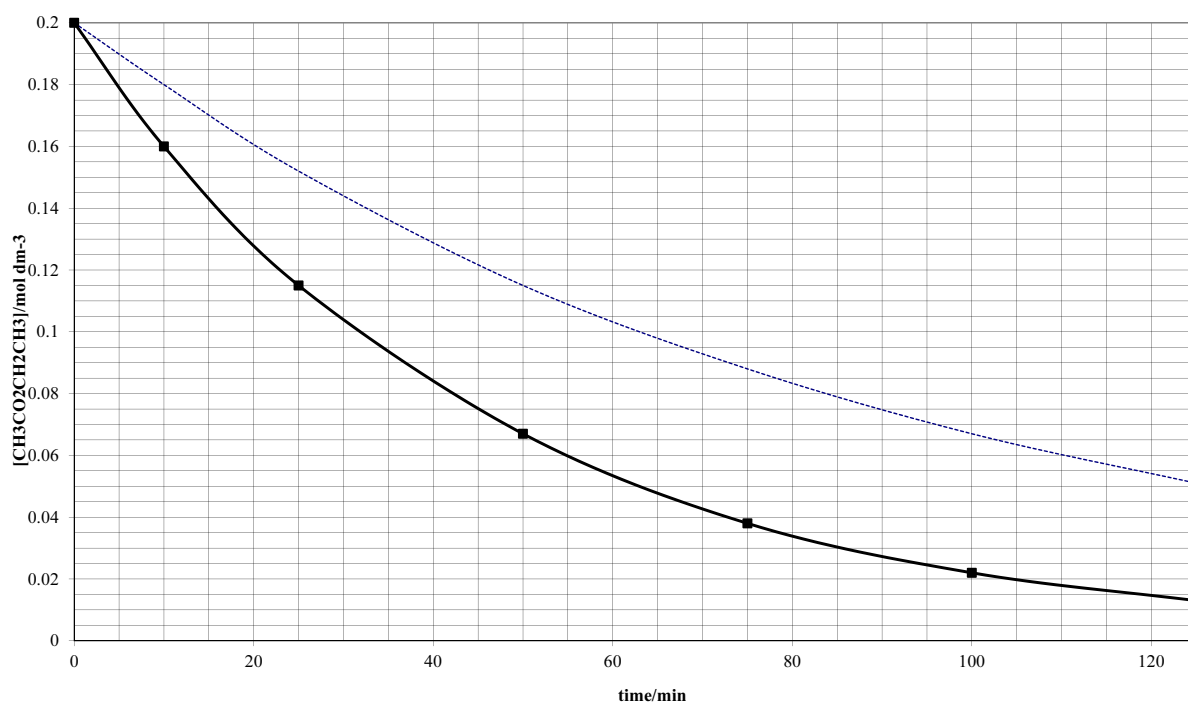
- H₂ and good delivery system [1]
Fe²⁺/Fe³⁺ solution labelled [1]
platinum electrodes (both) [1]
salt bridge and voltmeter [1]
H⁺ or HCl or H₂SO₄ [1]
(acid is not sufficient) [5]

- (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	43

2 (a) (i)



plotting of points (–1 for any error – plotted to within $\frac{1}{2}$ square) [1]
a good best fit curve [1]

(ii) construction lines for two half-lives **and** $t_{1/2} \approx 63 \text{ m}$ or 32 m ($\pm 3 \text{ min}$) / $t_{1/2}$ 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. $[\text{HCl}]$ [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} ($\text{mol dm}^{-3} \text{ min}^{-1}$) [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 ($\text{mol}^{-1} \text{ dm}^3 \text{ min}^{-1}$) [1]

[8 max 7]

(b) (i) because H_2O 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	43

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	43

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]

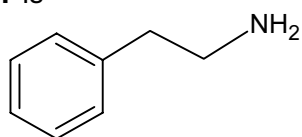
(d) (i) step 1: nucleophilic substitution [1]

step 2: hydrolysis [1]

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

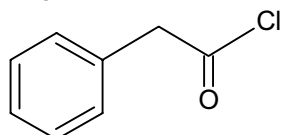
step 2: H_3O^+ / aqueous acid **and** reflux [1]

(iii) T is



[1]

W is



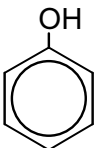
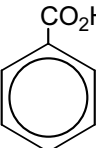
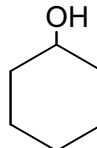
[1]

[6]

[Total: 15]

Page 6	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – May/June 2013	9701	43

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]

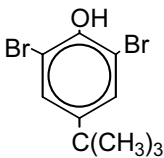
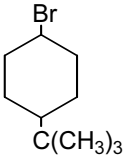
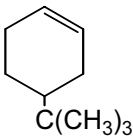
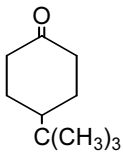
(iv) reflux [1]

dilute HCl [1]

[5]

Page 7	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – May/June 2013	9701	43

(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	43

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	43

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]

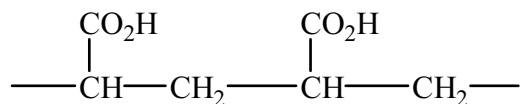
drugs: gas-liquid
or
thin-layer chromatography

[1]
[3]

[Total: 10]

Page 10	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – May/June 2013	9701	43

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]