CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the May/June 2014 series

9701 CHEMISTRY

9701/41 Paper 4 (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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CAMBRIDGE
International Examinations

Section A

1 (a) (i) m. pt. is high(er) / large(r) / greater (for iron) [1]
density is high(er) / large(r) / greater (for iron) [1]

(ii) (higher m. pt. due to)
strong attraction between cations and electrons *or*
more delocalised electrons [1]

(higher density due to) greater A_r **and** smaller radius [1]

(b) (i) components to be added: voltmeter *or* **V** [1]
salt bridge [<u>must be</u> labelled] [1]

(ii)

M1:	**A** and **B**	copper (metal) or Cu **and** iron (metal) or Fe	[1]
M2:	either **C** or **D**	as 1 mol dm^{-3} / 1 M	[1]
M3	**C** and **D**	Cu^{2+} or $CuSO_4$ or $CuCl_2$ or Cu $(NO_3)_2$ etc. **and** Fe^{2+} or $FeSO_4$ etc.	[1]

(iii) $E^{\ominus}_{cell}$ = 0.34 + 0.44 = **0.78** (V) [1]

(iv) if **C** is Fe^{2+}; (as [**C**] increases), the *E* of the Fe^{2+} / Fe increases / becomes more positive / less negative [1]

so the overall cell potential / E_{cell} would **decrease / become less positive / more negative** [1]

or

if **C** is Cu^{2+}; (as [**C**] increases), the E of the Cu^{2+}/Cu increases / becomes more positive / less negative [1]

so the overall cell potential / E_{cell} would **increase / become more positive / less negative** [1]

(c) (i) (colour change is) colourless to pink/pale purple
or (end point is the first) permanent (pale) pink/pale purple colour [1]

(ii) {n(MnO_4^-) = 0.02 × 18.1/1000 = 3.62 × 10^{-4} mol}
n(Fe^{2+}) = 5 × n(MnO_4^-) = **1.81 × 10^{-3} mol** [1]

mass of Fe = 55.8 x 1.81 × 10^{-3} = 0.101 g (M2 × 55.8) ecf [1]

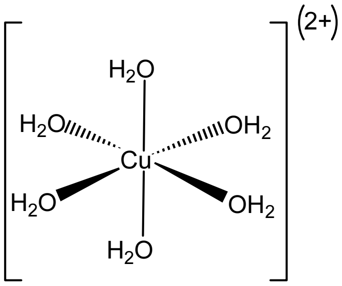
M_r = mass / moles = 0.500/1.81 × 10^{-3} = **276.2** ecf [1]

[Total: 16]

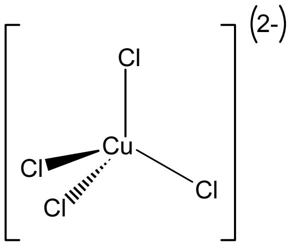
2 (a) (i) A *complex* is a compound / molecule / species / ion formed by a central metal atom / ion surrounded by / bonded to one or more ligands / groups / molecules / anions [1]

A *ligand* is a species that contains a **lone pair** of electrons that forms a **dative bond** to a metal atom / ion / *or* a lone pair donor to metal atom / ion [1]

(ii)

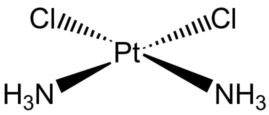


and



correct 3D structures: [1] + [1]
octahedral and tetrahedral [1]

(iii)



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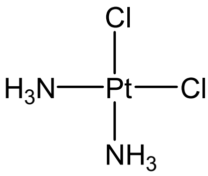

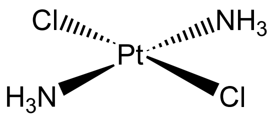

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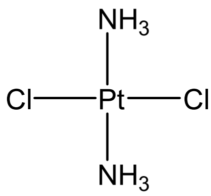


both structures [1]
geometric or cis-trans [1]

(b) (i) Cu(II) is [Ar] $3d^9$ [1]
Cu(I) is [Ar] $3d^{10}$ [1]

(ii) Cu(II): d orbitals / subshell are split (in ligand field) **and**

electron moves from lower to upper orbital *or* an electron is promoted / excited

in doing so it **absorbs** a photon / light [2]

Cu(I): no gap in upper orbital / all orbitals are full [1]

(c) (i) $\Delta H^{\ominus}$ = +2 × 33.2 – 157.3 + 302.9 = (+) 212 kJ mol^{-1} ecf [2]

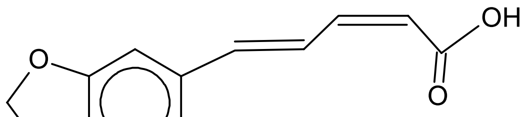
(ii) $\Delta H^{\ominus}$ = –168.6 + 2 × 157.3 = (+)146 kJ mol^{-1} **allow** ecf from **(c)(i)** [1]
high T / temperature since ΔH is positive / endothermic [1]

[Total: 16]

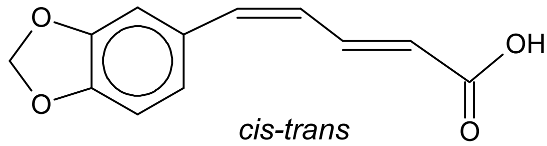
3 (a) heat in dilute HCl(aq) (or H_2SO_4(aq)) [1]

(b) (i) four isomers [1]

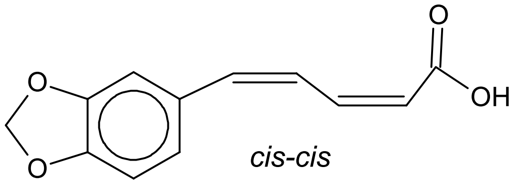
(ii) **must be skeletal**



trans-cis



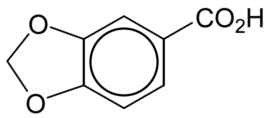
cis-trans



cis-cis

[1]

(iii)



+ CO_2 *or* $HO_2C\text{-}CO_2H$

[1] [1]

(c) (i) $K_w = [H^+][OH^-]$ [1]

(ii) In 0.15 mol dm^{-3} NaOH, $[OH^-]$ = 0.15 mol dm^{-3}
$[H^+] = K_w/[OH^-]$, so $[H^+] = 1 \times 10^{-14}/0.15 = 6.67 \times 10^{-14}$ mol dm^{-3} [1]
pH = $-\log_{10}[H^+]$ = **13.18 (13.2)** ecf from $[H^+]$ [1]

(iii) piperidine is a poorer proton acceptor
or piperidine is partially ionised [1]

(iv) piperidine should be a **stronger base/more basic** than ammonia
because of the electron-donating (alkyl/CH_2) groups [1]

(d) (i) n(HCl) at start = $0.1 \times 20/1000 = 2.0 \times 10^{-3}$ mol
n(HCl) at finish = $2 \times 10^{-3} - 1.5 \times 10^{-3}$ = **0.0005/5 × 10^{-4}** mol [1]

(ii) this is in 30 cm^3 of solution, so [HCl] at finish = $0.5 \times 10^{-3}/0.030$ **=** 1.67×10^{-2} mol dm^{-3}
pH = $-\log_{10}(1.67 \times 10^{-2})$ = **1.78** ecf from **(d)(i)** [1]

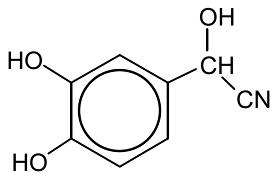
(iii) pH/vol curve: start at pH 11.9 [1]
vertical portion at V = 15 cm^3 [1]
levels off at pH 1.8 [1]

(iv) indicator is **B** [1]

[Total: 16]

4 (a) **three** from phenol
(secondary) alcohol
(primary) amine
arene/aryl/benzene $3 \times$ [1]

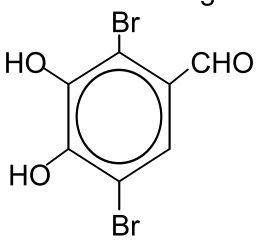
(b) (i)

Compound **Z** is 

[1]

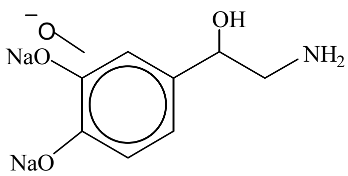
step 1: HCN + NaCN *or* HCN + base [1]
step 2: H_2 + Ni *or* $LiAlH_4$ *or* Na + ethanol [1]

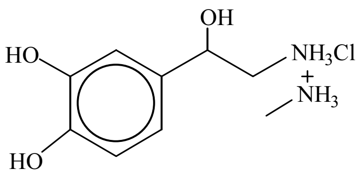
(ii) bromine decolourises *or* goes from orange to colourless *or* white ppt. formed [1]

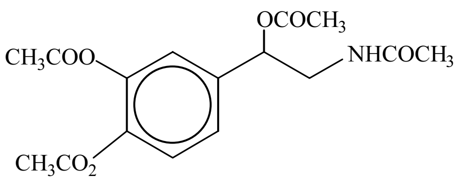
e.g.  2 or 3 bromines in ring

[1]

(c)

(i)  (*or* ionic) [1]

(ii)  (*or* ionic) [1]

(iii) 

M1: amide [1]
M2: alcoholic ester [1]
M3: <u>both</u> phenolic esters [1]
[5] max [4]

(d) amide [1]
ester [1]

[Total: 14]

5 (a) (i) –OH *or* hydroxyl groups (allow alcohol groups) [1]

(ii) alkenes *or* C=C (double) bonds *or* carbon double bonds [1]

(iii) $CH_3CH(OH)$ *or* CH_3CO- groups [1]

(b) **V** is $CH_3CH(OH)CH{=}CH_2$ [1]

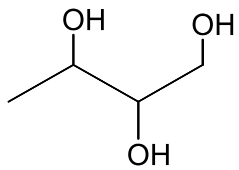
W is $CH_3CH{=}CHCH_2OH$ [1]

(c) compound **V** shows **optical** isomerism

(**ecf** for 'geometric(al)' if candidate's **V** is capable of cis-trans) [1]

[1]

(d)



or $CH_3CH(OH)CH(OH)CH_2OH$ [1]

[Total: 8]

6 (a)

feature	level of bonding
formation of α-helix	**secondary**
formation of disulfide bonds	**tertiary**
formation of ionic bonds	**tertiary**
linking amino acids	**primary**

[3]

(b)

block letter	name
J	Deoxyribose
K	Cytosine
L	Phosphate
M	Thymine

4 × [1]

(c) (i) H/hydrogen (bonds between bases) [1]

(ii) Bonds are weak **and**
so require relatively little energy to break / are easily broken [1]

(d)

	(sugar, **J**)	(base, **M**)
DNA	deoxyribose	thymine / T
RNA	ribose	uracil / U

[1]

[Total: 10]

7 (a) Expression: $n = \dfrac{100 \times 2.5}{1.1 \times 74}$ or equivalent [1]

$n = 3.1$ hence **G** has three carbon atoms [1]

(b) (i) (δ 1.1) RCH_3 *or* RCH_2R *or* methyl *or* CH_3

(δ 2.2) $(R)CH_2CO(R)$ *or* $CH_3CO(R)$

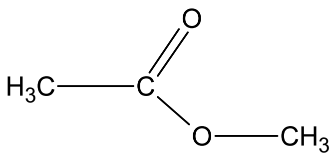
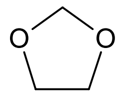
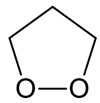
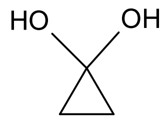
(δ 11.8) (R)COOH or (R)CONH(R) 3 × [1]

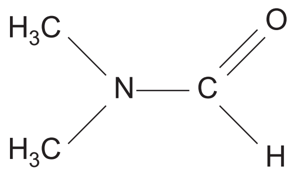
(ii) The (–OH) peak at δ 11.8 (disappears) [1]

because of (O)H-D exchange *or* equation showing this
(e.g. R-OH + $D_2O \rightleftharpoons$ R-OD + HOD) [1]

(iii) $CH_3CH_2CO_2H$ [1]

(c) (i)

 *or*  *or*  *or* 

or 

[1]

(ii) If methyl ethanoate: δ 2.0–2.1 [1]
δ 3.3–4.0 [1]

Or if 1, 3-dioxolane: δ 3.3–4.0 [1]
δ 3.3–5.0 [1]

Or if 1, 2-dioxolane: δ 0.9–1.4 [1]
δ 3.3–4.0 [1]

Or if dihydroxycyclopropane: δ 0.9–1.4 [1]
δ 0.5–6.0 [1]

[Total: 11]

8 (a) (i) Amide *or* ester *or* peptide [1]

(ii) Hydrolysis [1]

(iii) Drug **B** [1]

(iv) two ester and one amide groups circled [2]

(b) (i) At point **Q** because the hydrocarbon tails region is hydrophobic/non-polar/ form van der Waals **only** [1]
or can dissolve in the fat-soluble area

(ii) They all contain polar *or* hydrogen-bonding (groups) [1]

(c) (i) range 1×10^{-9} to 1×10^{-7} m [1]

(ii) (higher frequency radiation could) cause tissue/cell damage or mutation
or harmful to cells [1]

[Total: 9]