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

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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 [must be 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) {$n(MnO_4^-) = 0.02 \times 18.1/1000 = 3.62 \times 10^{-4}$ mol}
$n(Fe^{2+}) = 5 \times n(MnO_4^-)$ = **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 = $0.500/1.81 \times 10^{-3}$ = **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]

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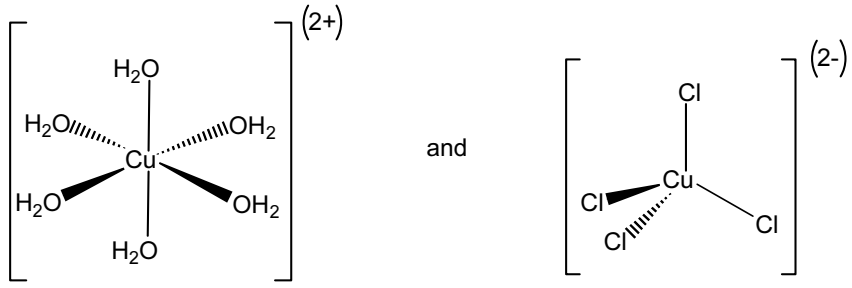
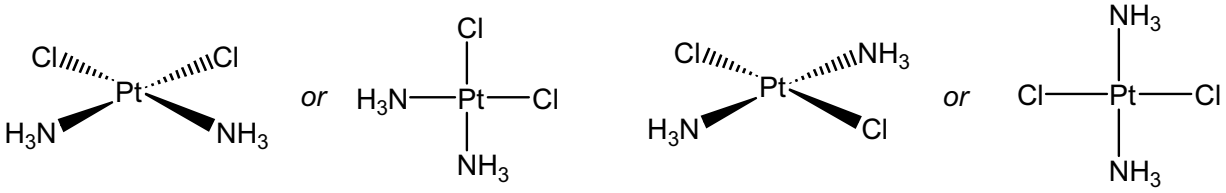
(ii)



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

(iii)



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

(ii) $\Delta H^{\ominus} = -168.6 + 2 \times 157.3 = (+)146\ \text{kJ mol}^{-1}$ **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]

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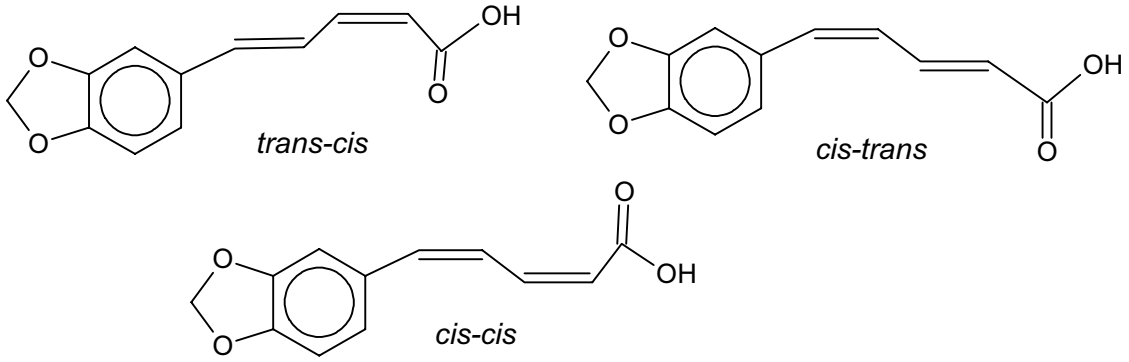
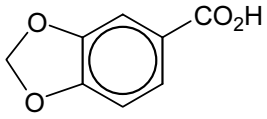
(ii) **must be skeletal**



[1]

(iii)



[1]

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

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

(ii) this is in 30 cm^3 of solution, so [HC*l*] 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 × [1]

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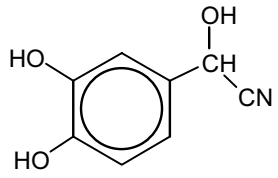
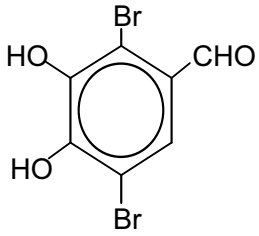
(b) (i)

Compound **Z** is 

[1]

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

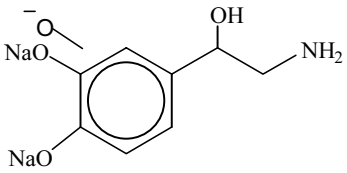
(ii) bromine decolourises *or* goes from orange to colourless *or* white ppt. formed [1]

e.g. 

2 or 3 bromines in ring

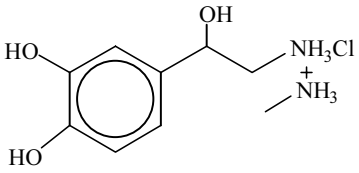
[1]

(c)

(i) 

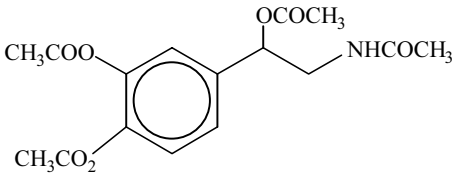
(*or* ionic)

[1]

(ii) 

(*or* ionic)

[1]

(iii) 

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

(d) amide [1]
ester [1]

[Total: 14]

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

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

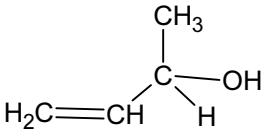
(iii) $CH_3CH(OH)$ *or* CH_3CO- groups [1]

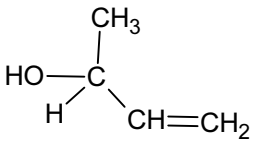
(b) **V** is $CH_3CH(OH)CH{=}CH_2$ [1]

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

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

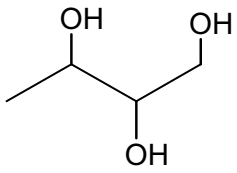
(ecf for 'geometric(al)' if candidate's **V** is capable of cis-trans) [1]





[1]

(d)



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

[Total: 8]

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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: $n = \frac{100 \times 2.5}{1.1 \times 74}$ 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]

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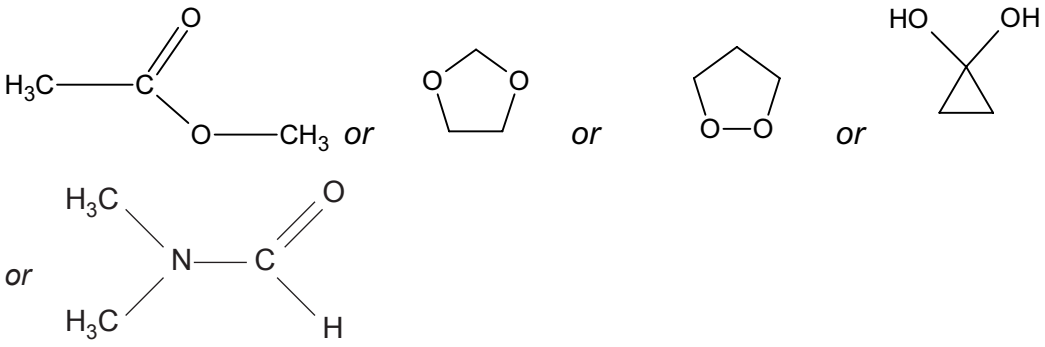
(ii) The (–OH) peak at δ 11.8 (disappears) [1]

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

(iii) $CH_3CH_2CO_2H$ [1]

(c) (i)



[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]

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