

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 $1 \text{ mol dm}^{-3} / 1 \text{ M}$ [1]
M3 **C and D** Cu^{2+} or CuSO_4 or CuCl_2 or $\text{Cu}(\text{NO}_3)_2$ etc. **and**
 Fe^{2+} or FeSO_4 etc. [1]
- (iii) $E^\circ_{\text{cell}} = 0.34 + 0.44 = \mathbf{0.78}$ (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) $\{n(\text{MnO}_4^-) = 0.02 \times 18.1/1000 = 3.62 \times 10^{-4} \text{ mol}\}$
 $n(\text{Fe}^{2+}) = 5 \times n(\text{MnO}_4^-) = \mathbf{1.81 \times 10^{-3} \text{ mol}}$ [1]

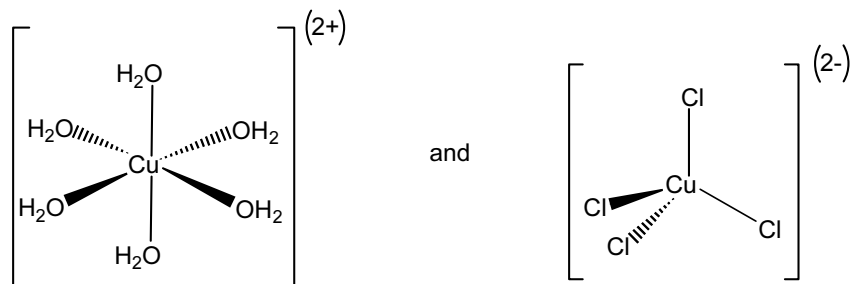
mass of Fe = $55.8 \times 1.81 \times 10^{-3} = 0.101 \text{ g}$ ($M_2 \times 55.8$) ecf [1]

 $M_r = \text{mass} / \text{moles} = 0.500 / 1.81 \times 10^{-3} = \mathbf{276.2}$ 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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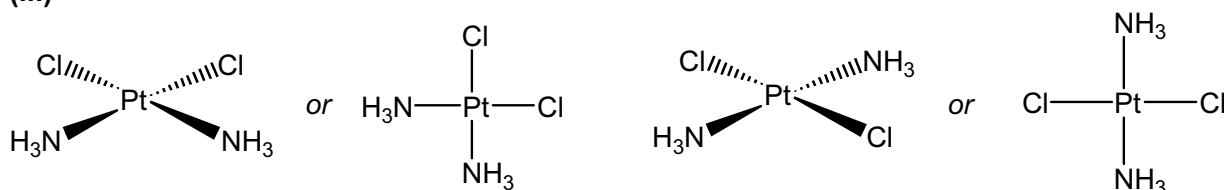
(ii)



correct 3D structures:
octahedral and tetrahedral

[1] + [1]
[1]

(iii)



both structures
geometric or cis-trans

[1]
[1]

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

(ii) $\text{Cu}(\text{II})$: 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]

$\text{Cu}(\text{I})$: no gap in upper orbital/all orbitals are full [1]

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

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

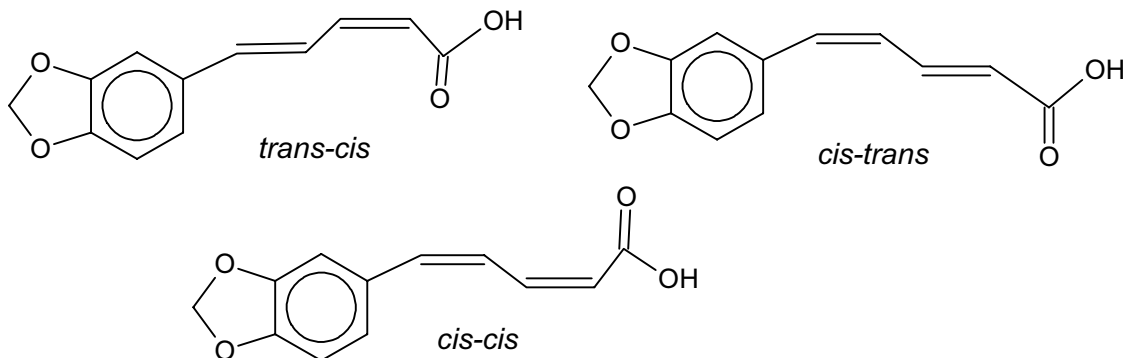
[Total: 16]

3 (a) heat in dilute $\text{HCl}(\text{aq})$ (or $\text{H}_2\text{SO}_4(\text{aq})$) [1]

(b) (i) four isomers [1]

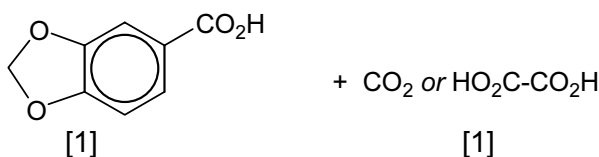
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(ii) must be skeletal



[1]

(iii)



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

(ii) In 0.15 mol dm⁻³ NaOH, $[OH^-] = 0.15 \text{ mol dm}^{-3}$
 $[H^+] = K_w/[OH^-]$, so $[H^+] = 1 \times 10^{-14}/0.15 = 6.67 \times 10^{-14} \text{ mol dm}^{-3}$ [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/CH₂) groups [1]

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

(ii) this is in 30 cm³ of solution, so $[HCl]$ at finish = $0.5 \times 10^{-3}/0.030 = 1.67 \times 10^{-2} \text{ mol dm}^{-3}$
 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 $V = 15 \text{ cm}^3$ [1]
 levels off at pH 1.8 [1]

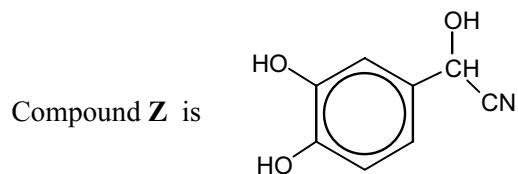
(iv) indicator is B [1]

[Total: 16]

4 (a) three from phenol
 (secondary) alcohol
 (primary) amine
 arene/aryl/benzene 3 × [1]

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(b) (i)



[1]

step 1: $\text{HCN} + \text{NaCN}$ or $\text{HCN} + \text{base}$

[1]

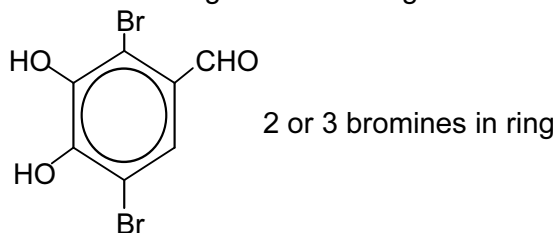
step 2: $\text{H}_2 + \text{Ni}$ or LiAlH_4 or $\text{Na} + \text{ethanol}$

[1]

(ii) bromine decolourises or goes from orange to colourless or white ppt. formed

[1]

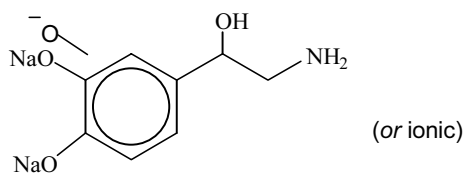
e.g.



[1]

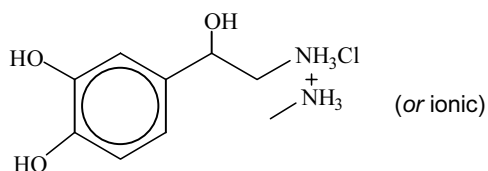
(c)

(i)



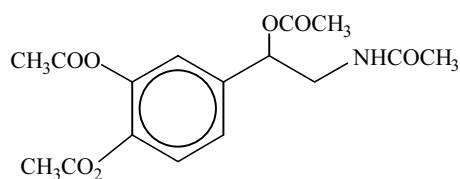
[1]

(ii)



[1]

(iii)



M1: amide

[1]

M2: alcoholic ester

[1]

M3: both phenolic esters

[1]

[5] max [4]

(d) amide
ester

[1]

[1]

[Total: 14]

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

(ii) alkenes or $\text{C}=\text{C}$ (double) bonds or carbon double bonds [1]

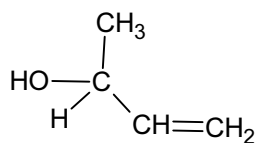
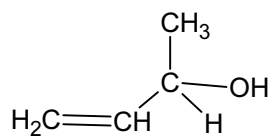
(iii) $\text{CH}_3\text{CH}(\text{OH})$ or $\text{CH}_3\text{CO-}$ groups [1]

(b) **V** is $\text{CH}_3\text{CH}(\text{OH})\text{CH}=\text{CH}_2$ [1]

W is $\text{CH}_3\text{CH}=\text{CHCH}_2\text{OH}$ [1]

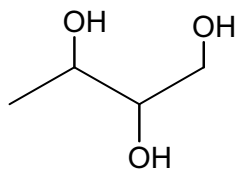
(c) compound **V** shows **optical** isomerism

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



[1]

(d)



or $\text{CH}_3\text{CH}(\text{OH})\text{CH}(\text{OH})\text{CH}_2\text{OH}$

[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) $(\text{R})\text{CH}_2\text{CO}(\text{R})$ or $\text{CH}_3\text{CO}(\text{R})$

(δ 11.8) $(\text{R})\text{COOH}$ or $(\text{R})\text{CONH}(\text{R})$

3 × [1]

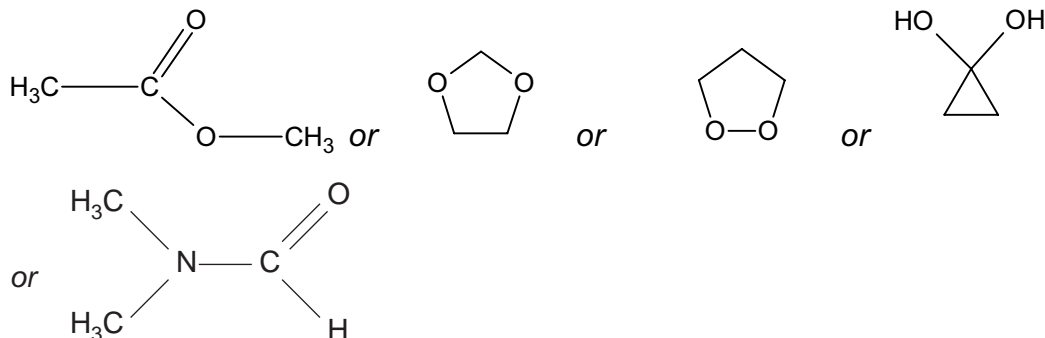
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(ii) The (–OH) peak at δ 11.8 (disappears) [1]

because of (O)H-D exchange *or* equation showing this
(e.g. $\text{R-OH} + \text{D}_2\text{O} \rightleftharpoons \text{R-OD} + \text{HOD}$) [1]

(iii) $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$ [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]