

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.

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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]

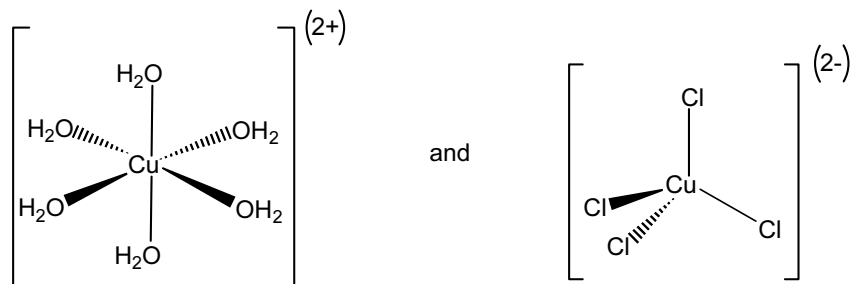
mass of Fe = $55.8 \times 1.81 \times 10^{-3} = 0.101 \text{ g}$ ($M_2 \times 55.8$) ecf [1]

 $M_r = \text{mass} / \text{moles} = 0.500 / 1.81 \times 10^{-3} = \mathbf{276.2}$ 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 **dativ e bond** to a
metal atom/ion/*or* a lone pair donor to metal atom/ion [1]

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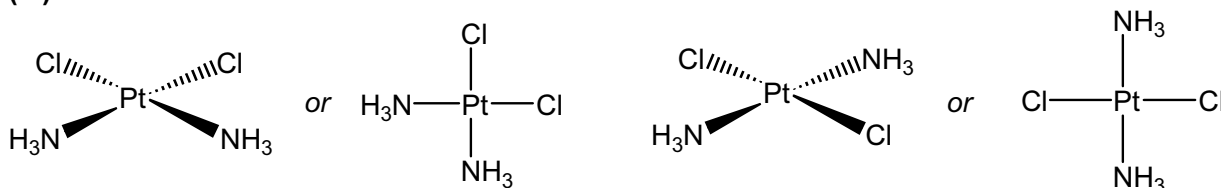
(ii)



correct 3D structures:
octahedral and tetrahedral

[1] + [1]
[1]

(iii)



both structures
geometric or cis-trans

[1]
[1]

(b) (i) Cu(II) is [Ar] 3d⁹ [1]
Cu(I) is [Ar] 3d¹⁰ [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/endergonic [1]

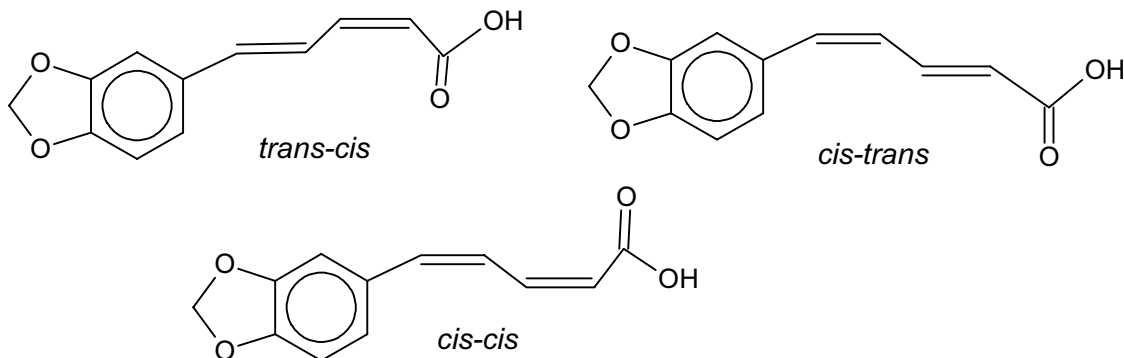
[Total: 16]

3 (a) heat in dilute HCl(aq) (or H₂SO₄(aq)) [1]

(b) (i) four isomers [1]

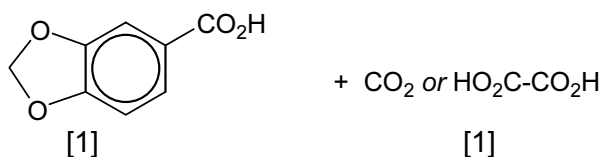
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(ii) must be skeletal



[1]

(iii)



(c) (i) $K_w = [\text{H}^+][\text{OH}^-]$ [1]

(ii) In 0.15 mol dm^{-3} NaOH, $[\text{OH}^-] = 0.15 \text{ mol dm}^{-3}$
 $[\text{H}^+] = K_w / [\text{OH}^-]$, so $[\text{H}^+] = 1 \times 10^{-14} / 0.15 = 6.67 \times 10^{-14} \text{ mol dm}^{-3}$ [1]
 $\text{pH} = -\log_{10}[\text{H}^+] = \mathbf{13.18}$ (13.2) ecf from $[\text{H}^+]$ [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) $n(\text{HCl})$ at start = $0.1 \times 20/1000 = 2.0 \times 10^{-3} \text{ mol}$
 $n(\text{HCl})$ at finish = $2 \times 10^{-3} - 1.5 \times 10^{-3} = \mathbf{0.0005/5 \times 10^{-4} \text{ mol}}$ [1]

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

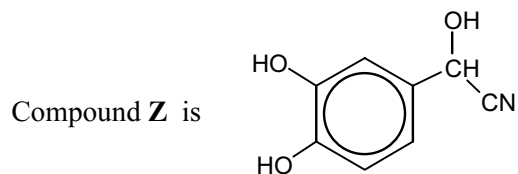
(iv) indicator is **B** [1]

[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: HCN + NaCN or HCN + base

[1]

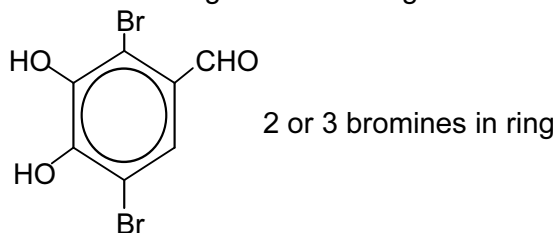
step 2: H₂ + Ni or LiAlH₄ or Na + ethanol

[1]

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

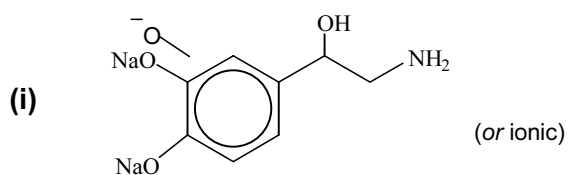
[1]

e.g.

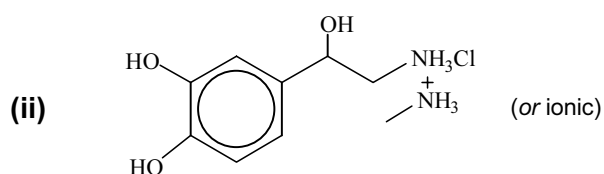


[1]

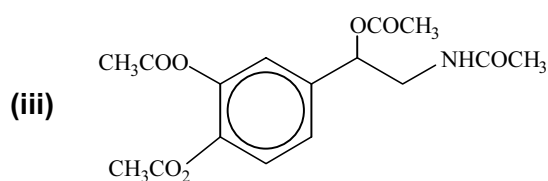
(c)



[1]



[1]



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 C=C (double) bonds or carbon double bonds [1]

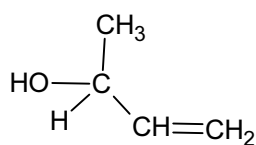
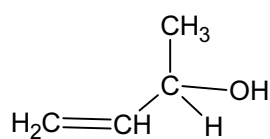
(iii) $\text{CH}_3\text{CH(OH)}$ or $\text{CH}_3\text{CO-}$ groups [1]

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

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

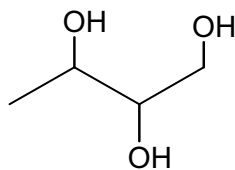
(c) compound **V** shows **optical** isomerism

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



[1]

(d)



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

[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) $(R)CH_2CO(R)$ or $CH_3CO(R)$ (δ 11.8) $(R)COOH$ or $(R)CONH(R)$

3 × [1]

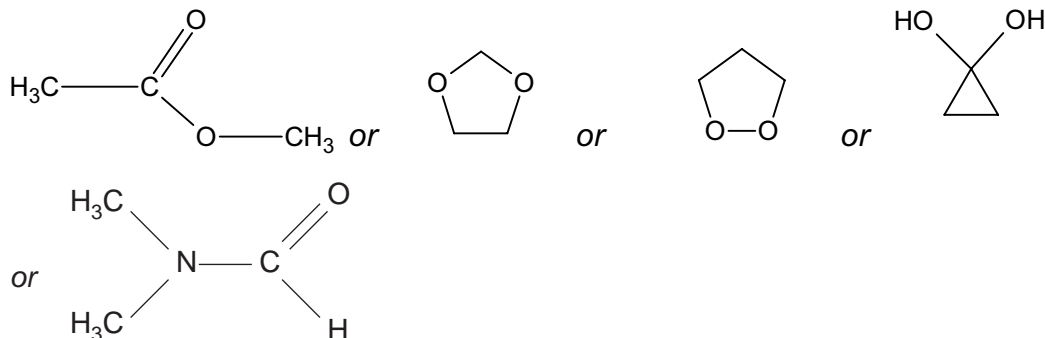
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(ii) The (–OH) peak at δ 11.8 (disappears) [1]

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