

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]

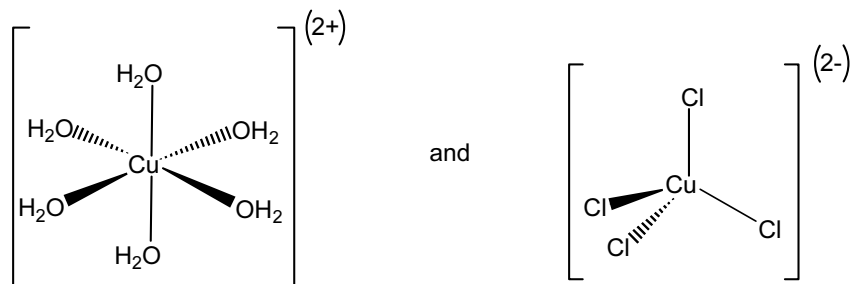
mass of Fe = $55.8 \times 1.81 \times 10^{-3} = 0.101 \text{ g}$ ($M_2 \times 55.8$) ecf [1]

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

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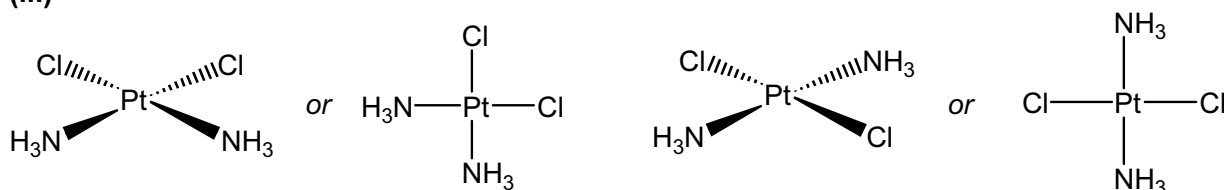
(ii)



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]

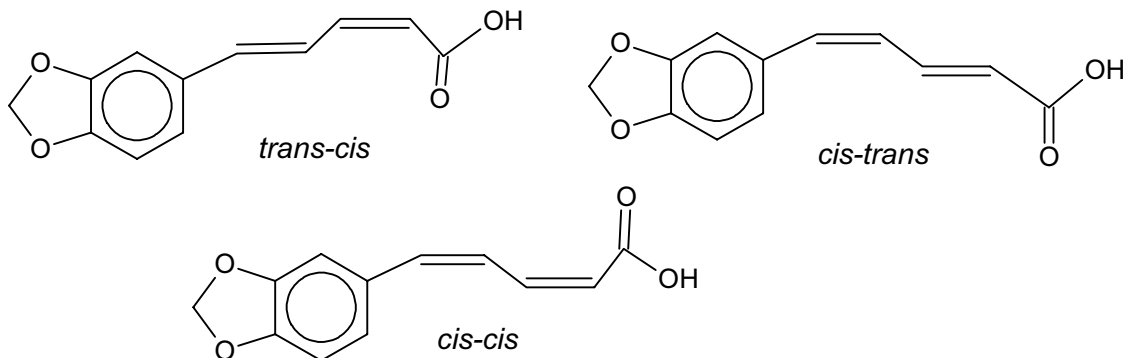
[Total: 16]

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

(b) (i) four isomers [1]

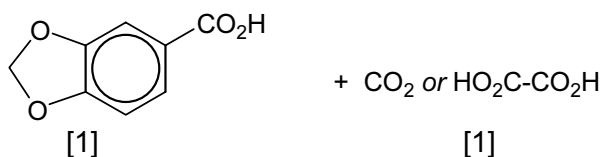
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(ii) must be skeletal



[1]

(iii)



(c) (i) $K_w = [\text{H}^+][\text{OH}^-]$ [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]
-\log_{10}[\text{H}^+] = 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 = $2 \times 10^{-3} - 1.5 \times 10^{-3} = 0.0005/5 \times 10^{-4} \text{ mol}$ [1]

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

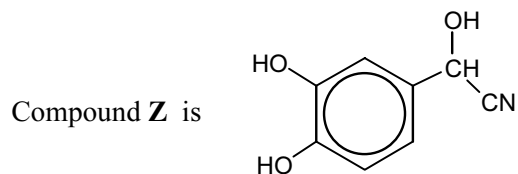
(iv) indicator is B [1]

[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]

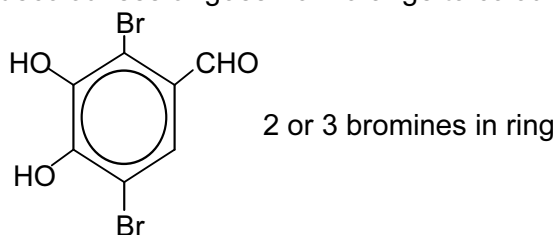
step 2: $\text{H}_2 + \text{Ni}$ or LiAlH_4 or $\text{Na} + \text{ethanol}$

[1]

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

[1]

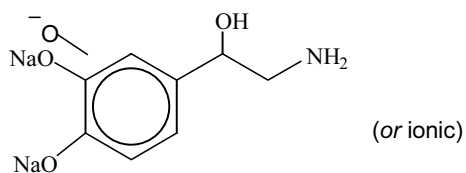
e.g.



[1]

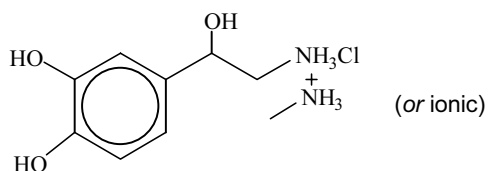
(c)

(i)



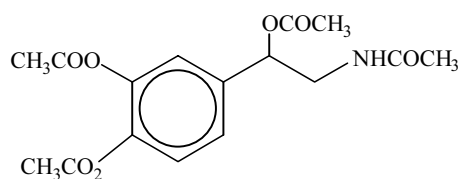
[1]

(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]

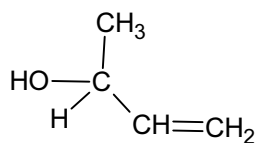
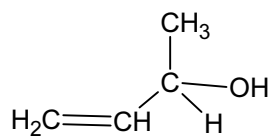
(iii) $\text{CH}_3\text{CH}(\text{OH})$ or $\text{CH}_3\text{CO-}$ groups [1]

(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]

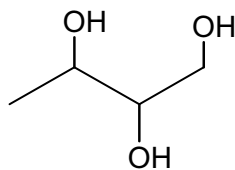
(c) compound **V** shows **optical** isomerism

(**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]

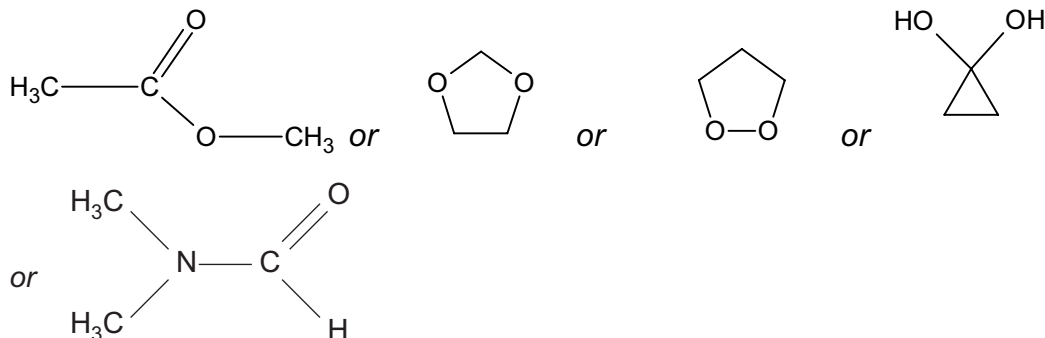
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(ii) The (–OH) peak at δ 11.8 (disappears) [1]

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]

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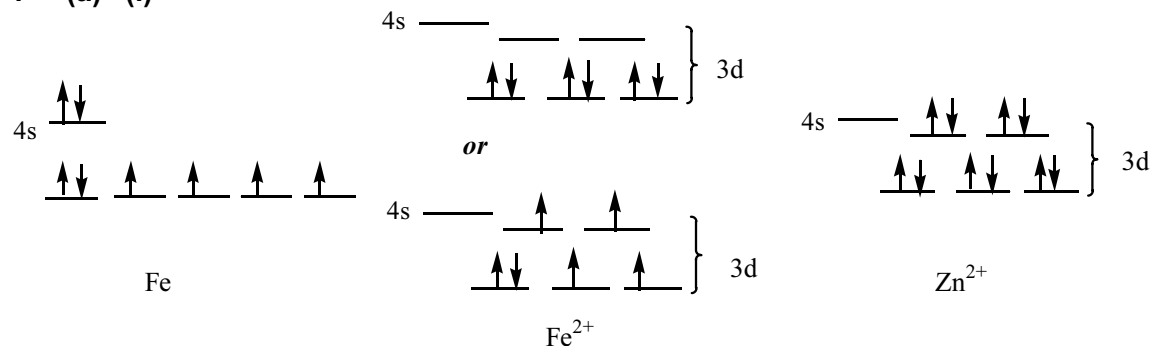
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1 (a) (i)



[2]

- (ii) (colour due to absorbance of visible light)
due to **electron** promoted (from lower) to upper **orbital / energy level**

[1]

in Zn²⁺ there's no space in higher orbital for the electron to go *or* completely filled **d**-orbitals / shell

[1]

4

- (b) (i) yellow is due to [CuCl₄]²⁻

[1]

reaction is ligand displacement / exchange

[1]

- (ii) (solution goes blue) due to [Cu(H₂O)₆]²⁺

[1]

blue **ppt. or (s)**
of Cu(OH)₂ *or* [Cu(H₂O)₄(OH)₂] etc.

[1]

[1]

purple *or* deep / dark blue **solution or (aq)**
due to [Cu(NH₃)₄]²⁺ *or* [Cu(NH₃)₄(H₂O)₂]²⁺

[1]

[1]

7

- (c) (i) $2\text{KI} + \text{K}_2\text{S}_2\text{O}_8 \longrightarrow 2\text{K}_2\text{SO}_4 + \text{I}_2$ *or*
ionic: $2\text{I}^- + \text{S}_2\text{O}_8^{2-} \longrightarrow 2\text{SO}_4^{2-} + \text{I}_2$

[1]

- (ii) Fe²⁺ is a **homogeneous catalyst**

[1]

- (iii) equations: $2\text{Fe}^{2+} + \text{S}_2\text{O}_8^{2-} \longrightarrow 2\text{Fe}^{3+} + 2\text{SO}_4^{2-}$
 $2\text{Fe}^{3+} + 2\text{I}^- \longrightarrow 2\text{Fe}^{2+} + \text{I}_2$

or verbal equivalent, e.g. reactants are both negative ions, so repel each other *or* Fe²⁺ can be oxidised by S₂O₈²⁻ **and** Fe³⁺ can be reduced by I⁻

[1]

3

[Total: 14]

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- 2 (a) **A:** voltmeter *or* V *or* potentiometer [1]
- B:** platinum *or* Pt [1]
- C:** 1 mol dm^{-3} **and** H^+ *or* HCl (*or* $0.5 \text{ M H}_2\text{SO}_4$) [1]
- D:** lead (metal) *or* Pb [1]
- 4**
- (b) (i) a ✓ in the box next to **–0.17 V** [1]
a comment that the $[\text{Pb}^{2+}]$ has decreased **plus** a description of the outcome, e.g. as $[\text{Pb}^{2+}]$ decreases (from 1 mol dm^{-3}), $\text{Pb}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Pb}(\text{s})$ goes over to the left hand side, *or* as $[\text{Pb}^{2+}]$ decreases, Pb^{2+} is less likely to be reduced [1]
- (ii) $(K_{\text{sp}} =) [\text{Pb}^{2+}][\text{Cl}^-]^2$ [1]
- (iii) if $[\text{PbCl}_2] = 3.5 \times 10^{-2}$, $[\text{Pb}^{2+}] = 3.5 \times 10^{-2}$ and $[\text{Cl}^-] = 7.0 \times 10^{-2}$
so $K_{\text{sp}} = (3.5 \times 10^{-2}) \times (7.0 \times 10^{-2})^2 = \mathbf{1.715 (1.7) \times 10^{-4} \text{ mol}^3 \text{ dm}^{-9}}$ ($\geq 2\text{sf}$) [1] + [1]
- 5**
- (c) (i) the $(\text{M}^{2+}/\text{M}) E^\ominus$ for the two elements are very similar *or* are -0.13 and -0.14 V [1]
 $E^\ominus (\text{Sn}^{4+}/\text{Sn}^{2+}) = 0.15 \text{ V}$ **and** $E^\ominus (\text{Pb}^{4+}/\text{Pb}^{2+}) = 1.69 \text{ V}$ [1]
so Sn^{2+} is quite easily oxidised (to Sn^{4+}) **or** is a stronger reductant **or** Pb^{2+} is not easily oxidised (to Pb^{4+}) **or** Pb^{4+} is a stronger oxidant **or** Pb^{4+} is easily reduced [1]
- (ii) e.g. $\text{PbCl}_2 + \text{Zn} \longrightarrow \text{Pb} + \text{ZnCl}_2$ (*or* ionic) [1]
(other acceptable reductants: Fe, Mg, Ca but **not** Na *or* K)
- $\text{Sn}^{2+} + \text{Br}_2 \longrightarrow \text{Sn}^{4+} + 2\text{Br}^-$ [1]
(other acceptable oxidants: VO^{2+} , $\text{Cr}_2\text{O}_7^{2-}$, Ag^+ , Cl_2 , Br_2 , F_2 , Fe^{3+} , MnO_4^-)
- 5**
- (d) (i) $\text{Pb}^{2+}(\text{g}) + 2\text{Cl}^-(\text{g}) \longrightarrow \text{PbCl}_2(\text{s})$ [1]
- (ii) $\Delta H_f = \Delta H_{\text{at}} + E(\text{Cl} - \text{Cl}) + 1^{\text{st}} \text{IE} + 2^{\text{nd}} \text{IE} + 2 \times E_{\text{A}}(\text{Cl}) + \text{LE}$
 $-359 = 195 + 242 + 716 + 1450 - 2 \times 349 + \text{LE}$
 $\text{LE} = 2 \times 349 - 359 - 195 - 242 - 716 - 1450$
 $\text{LE} = \mathbf{-2264 \text{ (kJ mol}^{-1}\text{)}}$ [3]
- (iii) $\text{LE}(\text{PbCl}_2) > \text{LE}(\text{PbBr}_2)$ *or* more exothermic *or* stronger lattice [1]
because Cl^- / chloride anion has smaller radius / size than Br^- / bromide [1]

6

[Total: 20]

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- 3 (a) (i) B and D [1] + [1]
- (ii) D [1]
- 3
- (b) heat with dilute $\text{H}^+(\text{aq})$ or $\text{H}_2\text{SO}_4(\text{aq})$ [1]
- 1
- (c) (i) K_a larger than that for ethanol because
the ethanoate ion/ CH_3CO_2^- is stabilised by charge delocalisation
or
the O–H bond is weakened due to its proximity to C=O/carbonyl group or
the second electronegative/oxygen atom [1]
- K_a smaller than that for chloroethanoic acid because
electron-withdrawing/electronegative chlorine (atom) makes the anion more
stable or O–H bond weaker or H more easily lost [1]
- (ii) $[\text{H}^+] = \sqrt{([\text{CH}_3\text{CO}_2\text{H}] \times K_a)} = \sqrt{(0.1 \times 1.75 \times 10^{-5})} = 1.32(3) \times 10^{-3} \text{ (mol dm}^{-3}\text{)}$ [1]
- $\text{pH} = -\log_{10}[\text{H}^+] = 2.88 \text{ (2.9)}$ [1]
- 4
- (d) (i) $n(\text{NaOH})$ at start = $0.1 \times 20/1000 = 2.0 \times 10^{-3} \text{ mol}$
 $n(\text{NaOH})$ at finish = $1.0 \times 10^{-3} \text{ mol}$ [1]
- (ii) this is in 30 cm^3 of solution,
so $[\text{NaOH}]$ at finish = $1.0 \times 10^{-3}/0.030 = 3.3(3) \times 10^{-2} \text{ mol dm}^{-3}$ (≥ 2 s.f.) ecf
from (i) [1]
- (iii) $[\text{H}^+] = K_w/[\text{OH}^-] = 1 \times 10^{-14}/3.33 \times 10^{-2} = 3.0 \times 10^{-13} \text{ mol dm}^{-3}$
 $\text{pH} = -\log_{10}[\text{H}^+] = 12.5(2)$ [1]
- or $\text{pOH} = -\log_{10}(3.33 \times 10^{-2}) = 1.48$
 $\text{pH} = \text{p}K_w - \text{pOH} = 14 - 1.48 = 12.5(2)$ [1]
- (iv) pH/vol curve: start at pH 2.88 (2.9) ecf [1]
- vertical (over at least 2 pH units) portion at $V = 10 \text{ cm}^3$ [1]
- levels off at pH 12.5 ± 0.3 ecf [1]
- (v) indicator is thymolphthalein [1]
- 7

[Total: 15]

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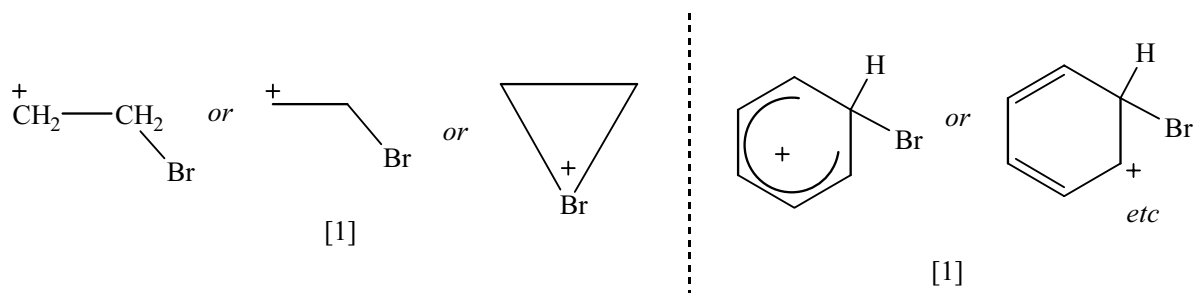
4. (a) (i) addition
AND
(ii) substitution [1]

1



1

- (c) (i) The two intermediate cations:



- (ii) The ring (of π electrons) in benzene is a stable configuration or is unchanged after the reaction. [1]

3

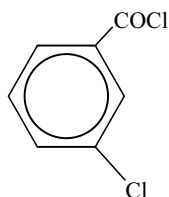
- (d) E is benzoic acid [1]

reaction 1: heat with KMnO_4 (+ OH^- or H^+) [1]

reaction 2: heat with $\text{Cl}_2 + \text{AlCl}_3$ or FeCl_3 [1]

3

- (e) G is [1]



reaction 3: SOCl_2 or PCl_5 [1]

reaction 4: LiAlH_4 [1]

3

[Total: 11]

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5. (a) (i) Na reacts with –OH or hydroxyl/ alcohol groups [1]

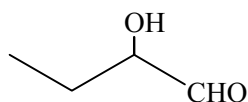
(ii) Fehling's solution reacts with –CHO or aldehyde groups [1]

2

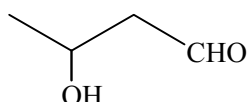
(b) alkene or C=C or carbon double bond or phenol or phenylamine [1]

1

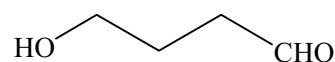
(c) $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CHO}$



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



$\text{HOCH}_2\text{CH}_2\text{CH}_2\text{CHO}$



[1] + [1] + [1]

3

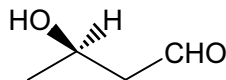
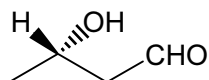
(d) (i) the $\text{CH}_3\text{CH}(\text{OH})$ group or the CH_3CO group or methyl secondary alcohol or methyl ketone [1]

(ii) $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CHO}$ [1]

2

(e) (i) optical isomerism [1]

(ii)



[1]

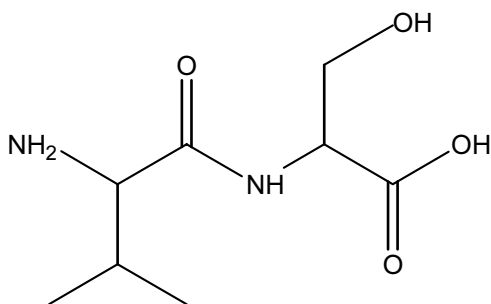
2

[Total: 10]

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Section B

6. (a) (i)



Peptide bond correct

Rest of structure correct (skeletal, displayed or structural formula, or a mix)

[1]

(ii) Condensation *or* nucleophilic substitution *or* addition-elimination

[1]

(iii) Water / H₂O

[1]

4

(b)

DNA	RNA
Contains deoxyribose	Contains ribose
Contains thymine / T	Contains uracil / U
Double strand / chain / helix <i>or</i> two strands	Single strand / chain

[3]

3

(c) (i) (met) - leu - thr - pro - glu

[1]

(ii) Mutations *or* addition / insertion / deletion / substitution / replacement (of a base)

[1]

(iii) Changing A (*or* the 14th base) into U

[1]

3

[Total: 10]

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7 (a) (i) (Electrophoresis): the size / shape / M_r of the amino acid *or* its charge [1]

(ii) (Paper chromatography): the partition of the amino acid between, *or* the relative solubility of the compound in, the 2 phases *or* solvent/water and stationary phase/filter paper. [1]

2

(b) Use ninhydrin as a locating agent [1]

1

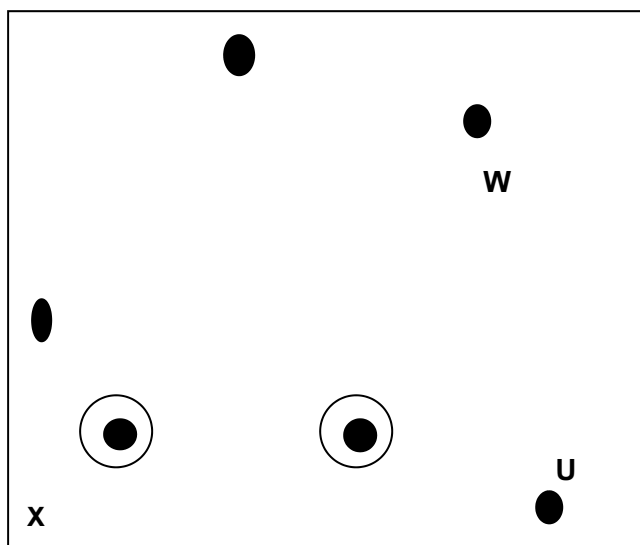
(c) The R_f value *or* retardation/retention factor *or* the distance travelled by the acid compared to that travelled by a standard sample of the amino acid [1]

1

(d) **R** – glutamic acid; **S** – glycine; **T** – lysine $3 \times [1]$

3

(e)



$3 \times [1]$

3

[Total: 10]

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8. (a) (i) Any addition polymer (e.g. polyethene, polypropene, polystyrene, PVC, PTFE, PVA, *Teflon*) [1]

(ii) Any condensation polymer (e.g. polyamide, polyester, nylon, *Terylene*, PET, PLA, *Kevlar*, *Nomex*) [1]

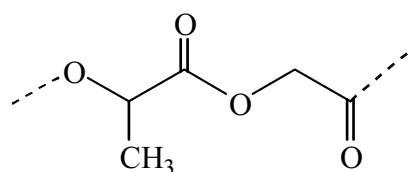
2

(b) Hydrolysis *or* nucleophilic substitution [1]

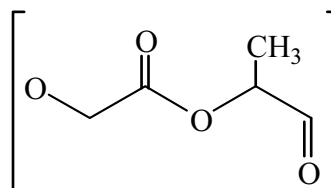
Ester **and** amide/peptide *or* $\text{--CO}_2\text{--}$ **and** --CONH-- [1]

2

(c)



or



Correct ester linkage [1]

CH_3 side chain on only one monomer unit [1]

2

(d) Plant materials do not generally contain unsaturated hydrocarbons/alkenes/ $\text{C}=\text{C}$ [1]

1

(e) (i) **Y** van der Waals' forces [1]

Z hydrogen bonding [1]

(ii) **Z**, because it can form hydrogen bonds with water *or* it contains polar CO and NH groups [1]

3

[Total: 10]

CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the May/June 2014 series

9701 CHEMISTRY

9701/43

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.

Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2014 series for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level components and some Ordinary Level components.

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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]

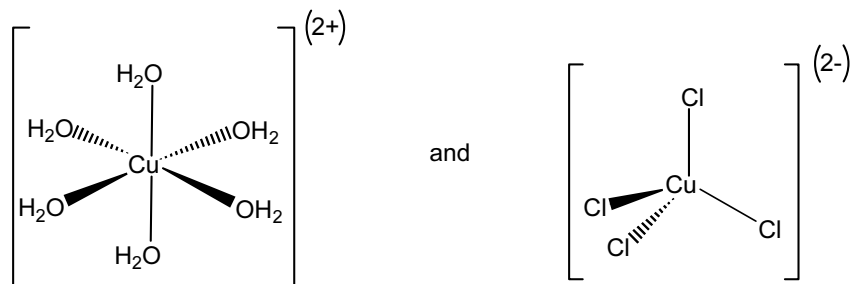
mass of Fe = $55.8 \times 1.81 \times 10^{-3} = 0.101 \text{ g}$ ($M_2 \times 55.8$) ecf [1]

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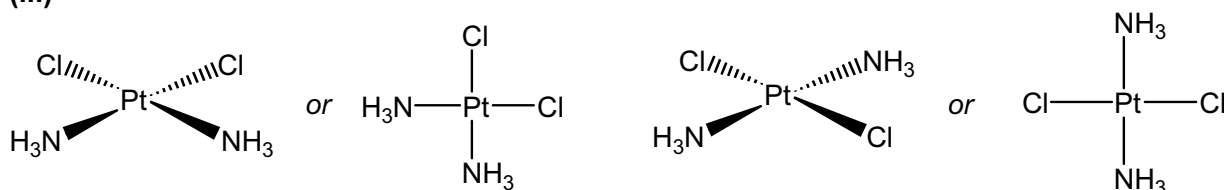
(ii)



correct 3D structures:
octahedral and tetrahedral

[1] + [1]
[1]

(iii)



both structures
geometric or cis-trans

[1]
[1]

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

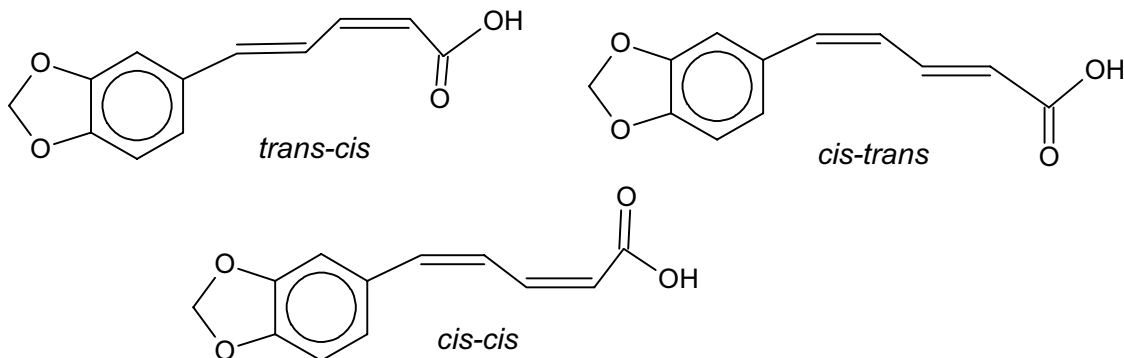
[Total: 16]

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

(b) (i) four isomers [1]

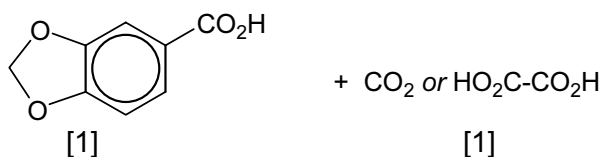
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(ii) must be skeletal



[1]

(iii)



(c) (i) $K_w = [\text{H}^+][\text{OH}^-]$ [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]
-\log_{10}[\text{H}^+] = 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 = $2 \times 10^{-3} - 1.5 \times 10^{-3} = 0.0005/5 \times 10^{-4} \text{ mol}$ [1]

(ii) this is in 30 cm³ of solution, so $[\text{HCl}]$ 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]

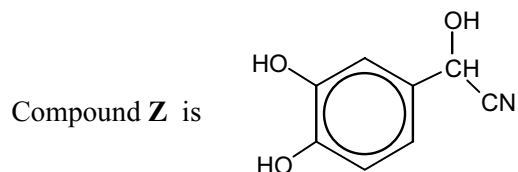
(iv) indicator is B [1]

[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]

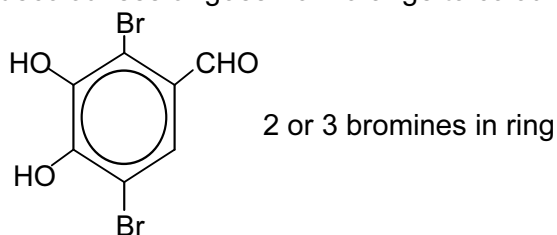
step 2: $\text{H}_2 + \text{Ni}$ or LiAlH_4 or $\text{Na} + \text{ethanol}$

[1]

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

[1]

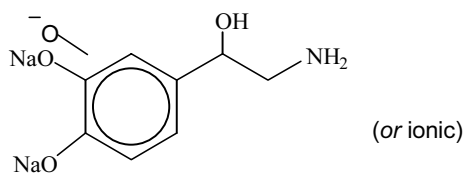
e.g.



[1]

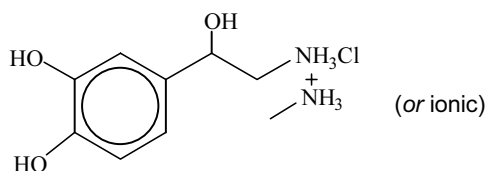
(c)

(i)



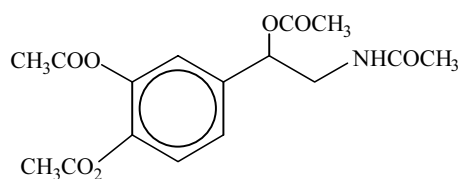
[1]

(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]

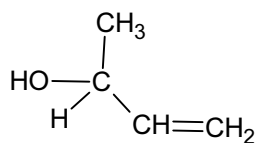
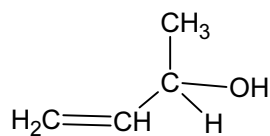
(iii) $\text{CH}_3\text{CH}(\text{OH})$ or $\text{CH}_3\text{CO-}$ groups [1]

(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]

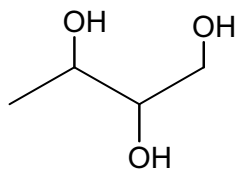
(c) compound **V** shows **optical** isomerism

(**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]

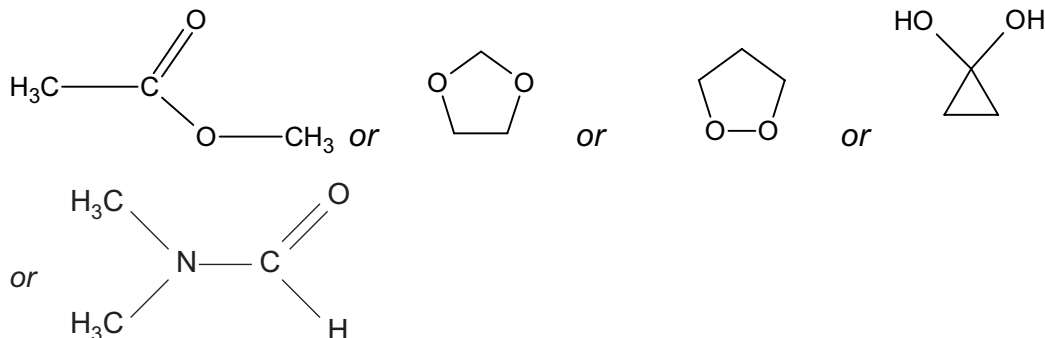
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(ii) The (–OH) peak at δ 11.8 (disappears) [1]

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]