CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the October/November 2013 series

9701 CHEMISTRY

9701/43 Paper 4 (A2 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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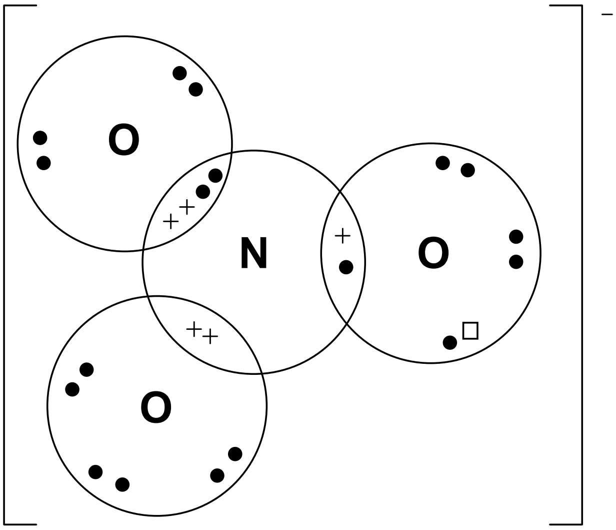
1 (a)



dative bond to an oxygen using two N electrons [1]
8 electrons around N in 1 double + 2 single bonds [1]
a total of 24 electrons, including one, and *only* one " " [1]
(the extra electron, " ", can be in a bond or a lone pair)

[3]

(b) (i) $2Mg(NO_3)_2 \longrightarrow 2MgO + 4NO_2 + O_2$ [1]

(ii) (down the group)
nitrates become more stable *or* are more difficult to decompose *or* need a higher temperature to decompose [1]

because there is less polarisation of the anion / nitrate ion **/** N–O bonds [1]

as radius of M^{2+} / metal ion increases *or* charge density of the cation decreases [1]

[4]

(c) $Cu + 4H^+ + 2NO_3^- \longrightarrow Cu^{2+} + 2NO_2 + 2H_2O$ species [1]
balancing [1]

[2]

[Total: 9]

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2 **(a)** *any two from*: molecules have negligible volume
negligible intermolecular forces *or* particles are not attracted to each other *or* to the walls of the container
random motion
no loss of **kinetic** energy during collisions *or* elastic collisions (NOT elastic molecules) 2 × [1]

[2]

(b) **(i)** low temperature ***and*** high pressure both required [1]

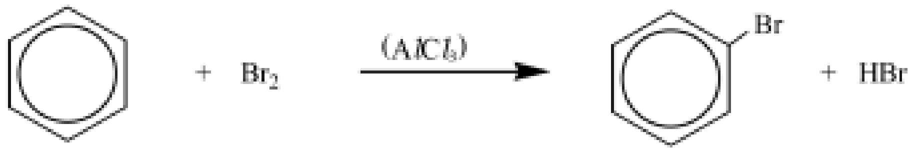
(ii) (at low T) forces between particles are more important, [1]

(at high P) volume of molecules are significant [1]

[3 max 2]

(c) **(i)** endothermic; because the equilibrium moves to the right on heating *or* with increasing temperature *or* because bonds are broken during the reaction [1]

(ii) e.g. halogenation *or* Friedel-Crafts alkylation / acylation



reactants [1]
products [1]

other possibilities: Cl_2, I_2, R–C*l*, RCOC*l* etc.

[3]

[Total: 7]

3 **(a)** **(i)** $CH_3Br(g) \longrightarrow CH_3(g) + Br(g)$ [1]

(ii) $^1/_3\, AlCl_3(g) \longrightarrow {}^1/_3 Al(g) + Cl(g)$ [2]
or $AlCl_3(g) \longrightarrow AlCl_2(g) + Cl(g)$
($AlCl_3(g) \longrightarrow Al(g) + 3Cl(g)$ for (1) mark)

[3]

(b) **(i)** bond energies decrease from Cl_2 to I_2 [1]
due to increasing bond length *or* increase in number of electron shells [1]
which causes less effective orbital overlap *or* less attraction for the shared pair [1]

(ii) *either* because fluorine is electronegative, (hence each F wants to keep its electrons to itself)
or because the bond length is so short there is repulsion between the lone pairs (on F)
or repulsion between the nuclei (of F) [1]

[4 max 3]

(c) **(i)** for chlorine:
ΔH = E(H – H) + E(Cl – Cl) – 2E(H – Cl) = 436 + 242 – (2 × 431)
= **–184** kJ mol^{-1} [2]
for iodine:
ΔH = E(H – H) + E(I – I) – 2E(H – I) = 436 + 151 – (2 × 299)
= **–11** kJ mol^{-1} [1]

(ii) Hydrides become less thermally stable down the group from Cl to I [1]
as the H–X bond energy decreases (more than does the X–X bond energy) [1]

[5]

(d) **(i)**

	Na	O	Br	
	15.2 / 23	31.8 / 16	53.0 / 79.9	[1]
⇒	0.661	1.99	0.663	
÷ 0.661 ⇒	1.0	3.0	1.0	

thus **$NaBrO_3$** [1]

(ii) $3Br_2 + 6NaOH \longrightarrow NaBrO_3 + 5NaBr + 3H_2O$
or $3Br_2 + 6OH^- \longrightarrow BrO_3^- + 5Br^- + 3H_2O$
species [1]
balancing [1]
[4]

[Total: 15]

4 **(a)** **(i)** Carbon (graphite) has delocalised electrons whereas silicon's electrons are localised. [1]

(ii) Tin has metallic structure *or* delocalised / mobile electrons whereas germanium has localised electrons *or* giant covalent structure [1]

[2]

(b) **(i)** $2PbO_2 \longrightarrow 2PbO + O_2$ [1]

(ii) $PbO_2 + 4HCl \longrightarrow PbCl_2 + Cl_2 + 2H_2O$ [1]

(iii) $SnO + 2NaOH \longrightarrow Na_2SnO_2 + H_2O$ [1]

(iv) $GeCl_4 + 2H_2O \longrightarrow GeO_2 + 4HCl$ [1]

[4]

[Total: 6]

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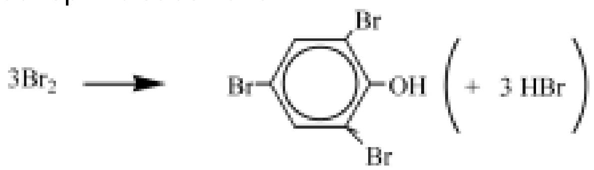
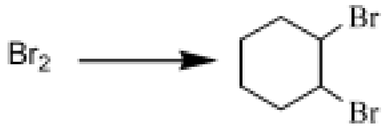
5 (a) (i) $Br_2(aq)$ [1]
electrophilic substitution [1]



[1]

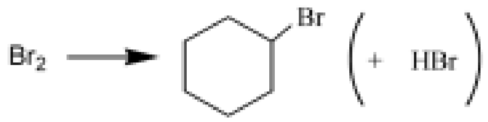
(ii) no special conditions [1]
electrophilic addition [1]



(allow bromohydrin *or* dibromide if $Br_2(aq)$ has been used)

product [1]

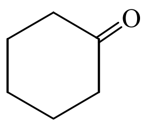
(iii) light / UV *or* heat [1]
(free) radical substitution [1]



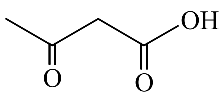
product [1]
balanced equation in (i) (i.e. $3Br_2$ and 3 HBr) [1]
balanced equation in (iii) (i.e. Br_2 and HBr) [1]

[11 max 10]

(b) (i)



C



D

CH_3CO_2H

E

3 correct structures (can be in any order) 3 × [1]

(ii) results of tests:

with 2,4–DNPH: **C** and **D** [1]
with I_2 + OH^-: **D** only [1]
with NaOH: **D** and **E** [1]

(N.B. letters may be different – must refer to the candidate's formulae)

[6]

[Total: 16]

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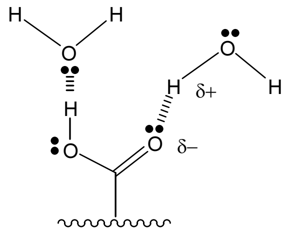
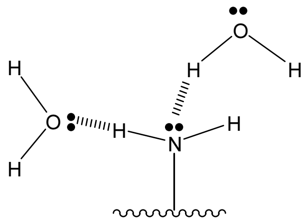
6 **(a)** A (Bronsted-Lowry) acid is a proton donor. [1]

[1]

(b) **(i)**



carboxylic acid



amino group

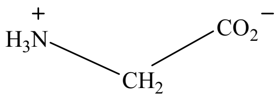
at least one H_2O molecule in the right orientation: attached to $–CO_2H$ [1]

attached to $–NH_2$ [1]

lone pair (on oxygen in H_2O *or* $–CO_2H$ *or* on nitrogen) shown at least once on a H-bond [1]

δ+ and δ– shown at least once (at each end of the same H-bond) [1]

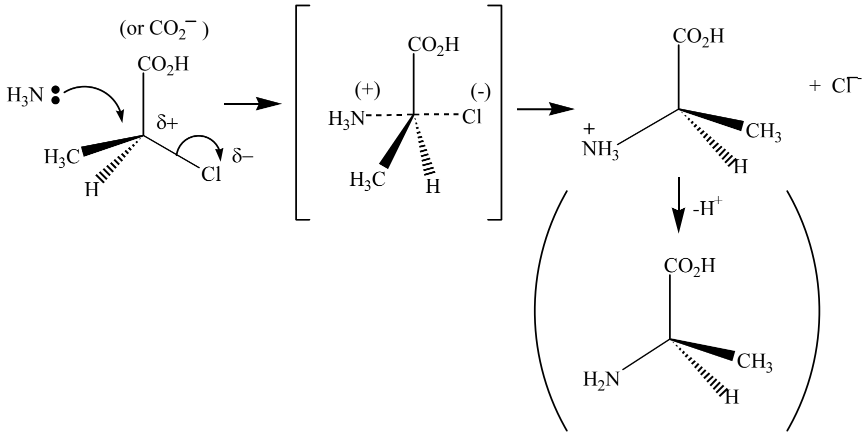
(ii)



[1]

[5]

(c) allow either S_N1 or S_N2



any three of δ+ and δ– shown in C–C*l*

curly arrow from **lone pair on NH_3** to (δ+) carbon

curly arrow from C–C*l* bond to C*l*

5-coordinate transition state *or* carbocation intermediate if S_N1, with correct charge

[3]

[3]

(d) lysine @ pH 1: $^+NH_3(CH_2)_4CH(NH_3^+)CO_2H$ [1]

aspartic acid @ pH 12: $^-O_2C\,CH_2\,CH(NH_2)CO_2^-$ [1]

[2]

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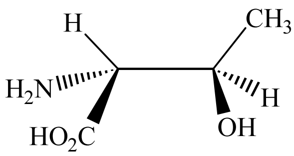
(e) **(i)** 6 (six) [1]

(ii) *either* $H_2NCH(CH_3)CO–NHCH(CH_2OH)CO_2H$
or $H_2NCH(CH_2OH)CO–NHCH(CH_3)CO_2H$ [2]
[3]

(f) **(i)** Compounds have the same **structural** formula but ....
different (spatial) arrangement / position *or* orientation of atoms in space [1]

(ii) **J** [1]

(iii)



[1]
[3]

[Total: 17]

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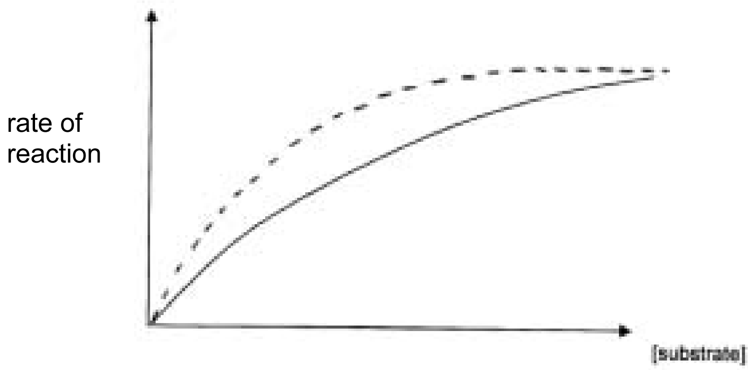
Section B

7 (a) (i) Metals such as Hg, Ag, Cd, Pb, Cu (identified – NOT just "heavy metals")
(allow names, atomic symbols or ions, names or formulae of salts – e.g. $Pb(NO_3)_2$)
or penicillin *or* organophosphorus insecticide etc. [1]

(ii) The ion/inhibitor binds to a part of the enzyme molecule away from the active site *or* to an allosteric site [1]
This changes the shape of the active site *or* denatures the enzyme [1]
OR
the inhibitor forms a **covalent/permanent** bond with the active site [1]
blocking entry of the substrate [1]

(iii)



[1]
[4]

(b) (i) (DNA) ⟶ **mRNA** ⟶ **ribosome** ⟶ **tRNA** ⟶(Protein) [2]

(ii) stop codon/it is used to stop the growth of a protein chain
(allow: used at the start of protein synthesis) [1]
[3]

(c) (i) Adenosine diphosphate (ADP) *or* AMP **and** (inorganic) phosphate/P_i/PO_4^{3-}/H_3PO_4 [1]

(ii) Any two of –
muscle contraction
transport of ions/molecules *or* active transport *or* exocytosis *or* Na/K pump
synthesis of new compounds/proteins etc.
movement of electric charge in nerve cells
bioluminescence
non-shivering thermogenesis
DNA synthesis/reproduction 2 × [1]
[3]

[Total: 10]

8 **(a)** NMR **and** radiowaves (*or* VHF / UHF *or* 40 – 800 MHz) [1]
[1]

(b) NMR: protons have (nuclear) spin
or (*s*pinning) proton produces magnetic moment / field *or* two spin states
or protons can align with or against an applied magnetic field [1]

there is insufficient electron density / cloud around H atoms for X-ray crystallography [1]
[2]

(c) Sulfur, because it has the highest electron density [1]
[1]

(d) **(i)** $\frac{4.5}{1.5} = \frac{100}{1.1} \times n$

$n = \frac{100 \times 0.15}{4.5 \times 1.1} = 3.03 = \mathbf{3}$ (calculation must be shown) [1]

(ii) the –OH peak (broad singlet) at δ 4.6 [1]

(iii) 3 (three) [1]

(iv) **Q** has peak at 11.7δ. [1]
which is due to $–CO_2H$ [1]
(This can only be formed by oxidising a *primary* alcohol.)

or **P** has 4 peaks in its NMR spectrum, not 3 [1]
in a secondary alcohol with 3 carbons, two (methyl) groups will be in the same chemical environment (or wtte) [1]

or analysis of the splitting pattern in **P**: the peaks at δ 0.9 and 3.6 are triplets, [1]
so each must be adjacent to a $–CH_2–$ group. (hence $–CH_2–CH_2–CH_3$) [1]

(v) $CH_3CH_2CO_2H$ (**structure** needed, not name) [1]
[6]

[Total: 10]

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9 (a) (i) diamond and graphite [1]

(ii) any three from

	graphite	**diamond**
colour	black	transparent / colourless
electrical conductivity	good conductor	non-conductor
hardness	soft / slippery	hard / non slippery
density	less dense than diamond	more dense than graphite
melting point	lower	higher

3 × [1]
[4]

(b) Because each carbon is only bonded to 3 others *or* is unsaturated / doubly-bonded / sp^2 *or* has 3 bonding locations
(NOT forms only 3 *bonds*) [1]

$C_{60}H_{60}$ [1]
[2]

(c) (i) Number of atoms carbon present = $0.001 \times 6.02 \times 10^{23} / 12 = \mathbf{5.02 \times 10^{19}}$ [1]

(ii) Number of hexagons present = $5.02 \times 10^{19} / 2 = 2.51 \times 10^{19}$

Area of sheet = $690 \times 2.51 \times 10^{19} = \mathbf{1.73 \times 10^{22}\ nm^2}$ [1]

(iii) Graphene: Yes, since it has free / delocalised / mobile electrons [1]

Buckminsterfullerene: No, (although there is delocalisation within each sphere)
it consists of separate / simple / discrete molecules / spheres / particles,
(so no delocalisation from one sphere to the next)
or electrons are trapped within each molecule / sphere [1]
[4]

[Total: 10]

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