**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

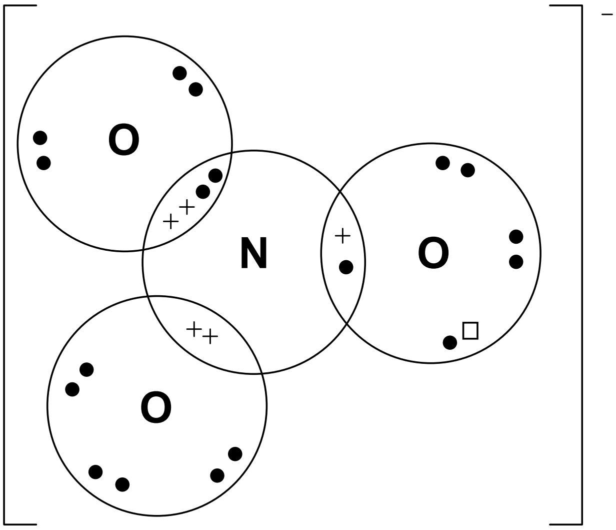
This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, 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.

Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the October/November 2013 series for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level components and some Ordinary Level components.

**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]**

**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]

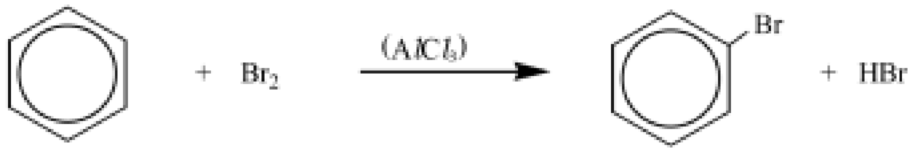
**(ii)** (at low T) forces between particles are more important, [1]

(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)** $^1/_3\,AlCl_3(g) \longrightarrow {}^1/_3Al(g) + Cl(g)$ [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:
$\Delta H = E(H-H) + E(Cl-Cl) - 2E(H-Cl) = 436 + 242 - (2 \times 431)$
$= \mathbf{-184}\ kJ\ mol^{-1}$ [2]
for iodine:
$\Delta H = E(H-H) + E(I-I) - 2E(H-I) = 436 + 151 - (2 \times 299)$
$= \mathbf{-11}\ kJ\ mol^{-1}$ [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] |
| $\Rightarrow$ | 0.661 | 1.99 | 0.663 | |
| $\div$ 0.661 $\Rightarrow$ | 1.0 | 3.0 | 1.0 | |

thus $\mathbf{NaBrO_3}$ [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]

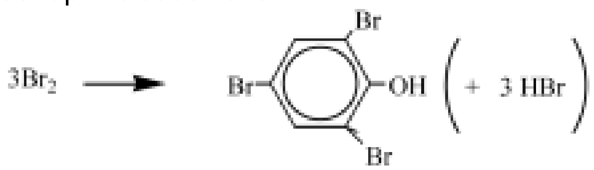
**(iii)** $SnO + 2NaOH \longrightarrow Na_2SnO_2 + H_2O$ [1]

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

**[4]**

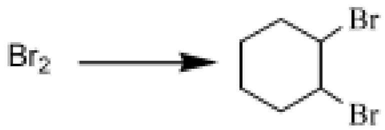
**[Total: 6]**

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



[1]

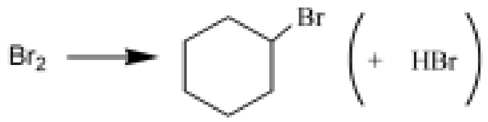
**(ii)** no special conditions [1]
electrophilic addition [1]



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

product [1]

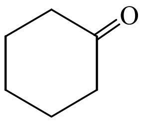
**(iii)** light / UV *or* heat [1]
(free) radical substitution [1]



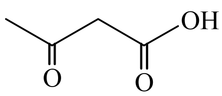
product [1]
balanced equation in (i) (i.e. $3\,Br_2$ and $3\,HBr$) [1]
balanced equation in (iii) (i.e. $Br_2$ and HBr) [1]

**[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)

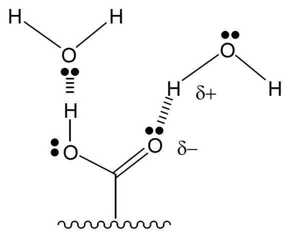
**[6]**

**[Total: 16]**

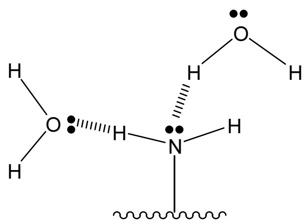
**6** **(a)** A (Bronsted-Lowry) acid is a proton donor. [1]

**[1]**

**(b)** **(i)**



carboxylic acid



amino group

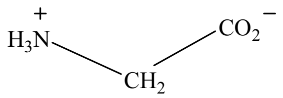
at least one $H_2O$ molecule in the right orientation: attached to $–CO_2H$ [1]

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]

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

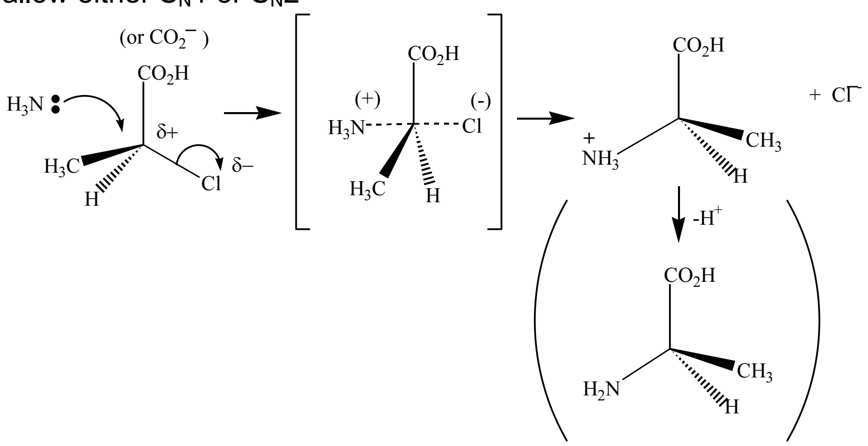
**(ii)**



[1]

**[5]**

**(c)** allow either $S_N1$ or $S_N2$



*any three* of
- $\delta+$ and $\delta–$ shown in C–C*l*
- curly arrow from **lone pair on $NH_3$** to ($\delta+$) 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]**

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

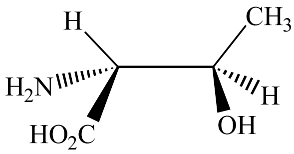
**(ii)** *either* $H_2NCH(CH_3)CO–NHCH(CH_2OH)CO_2H$
*or* $H_2NCH(CH_2OH)CO–NHCH(CH_3)CO_2H$ [2]

**[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]**

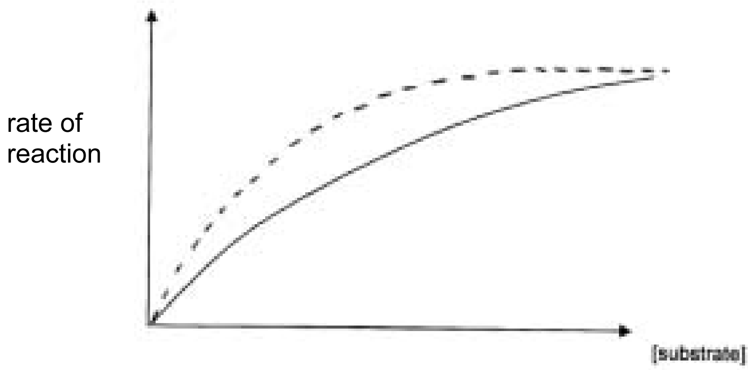
**[Total: 17]**

## 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 $\delta$ 4.6 [1]

**(iii)** 3 (three) [1]

**(iv)** **Q** has peak at 11.7$\delta$. [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 $\delta$ 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]**

**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]**