CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2013 series

9701 CHEMISTRY

9701/21 Paper 2 (AS Structured Questions), maximum raw mark 60

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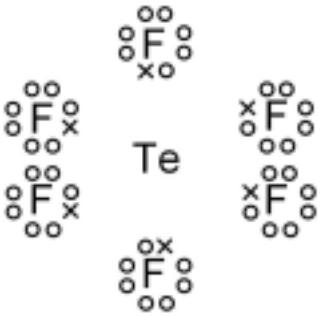
1 (a)

number of bond pairs	number of lone pairs	shape of molecule	formula of a molecule with this shape
3	0	trigonal planar	BH_3
4	0	tetrahedral	CH_4 allow other Group IV hydrides
3	1	pyramidal **or** trigonal pyramidal	NH_3 allow other Group V hydrides
2	2	non-linear **or** bent **or** V-shaped	H_2O allow other Group VI hydrides

1 mark for each correct row (3 × 1) [3]

(b) (i)



(1)

(ii) octahedral **or** square-based bipyramid (1)

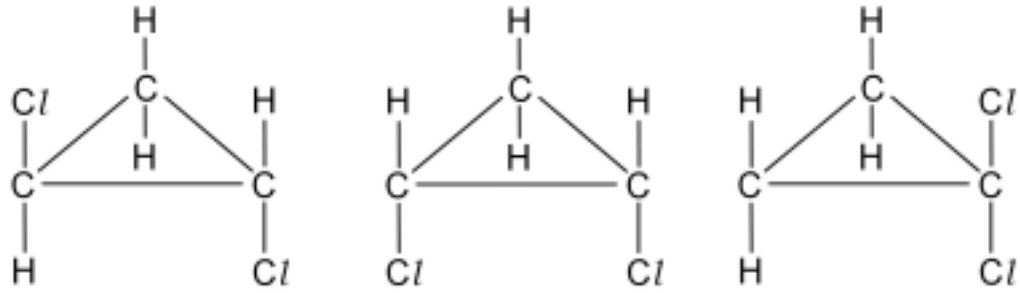
(iii) 90° (1) [3]

[Total: 6]

2 **(a)** 117° to 120° (1) [1]

(b) **(i)** electrophilic addition (1)

(ii)



1 mark for each correct structure
allow correctly drawn optical isomers of the first structure (3 × 1) [4]

[Total: 5]

3 **(a)** **(i)** **anode** $Cl^-(aq) \rightarrow \frac{1}{2} Cl_2(g) + e^-$ (1)

cathode $H^+(aq) + e^- \rightarrow \frac{1}{2}H_2(g)$ **or**
$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ (1)

(ii) because iron in steel will react with chlorine (1) [3]

(b) **sodium**
burns with a yellow **or** orange flame **or**
forms a white solid
allow – **once only** – colour of chlorine disappears (1)
$2Na + Cl_2 \rightarrow 2NaCl$ (1)

phosphorus
burns with a white **or** yellow flame **or**
colour of chlorine disappears – if **not** given for Na – **or**

for PCl_5 forms a white **or** pale yellow solid

for PCl_3 forms a colourless liquid (1)

$P + 2\frac{1}{2}Cl_2 \rightarrow PCl_5$ **or** $P_4 + 10Cl_2 \rightarrow 4PCl_5$

or

$P + 1\frac{1}{2}Cl_2 \rightarrow PCl_3$ **or** $P_4 + 6Cl_2 \rightarrow 4PCl_3$

equation must refer to compound described (1) [4]

(c) cold dilute aqueous NaOH

NaOCl (1)
+1 (1)

hot concentrated aqueous NaOH

NaClO$_3$ (1)
+5 (1) [4]

(d) MgCl_2 6.5 to 6.9 (1)

SiCl_4 0 to 3 (1)

MgCl_2 dissolves without reaction **or**
slight **or** partial hydrolysis occurs (1)

SiCl_4 reacts with water **or**
hydrolysis occurs (1)

SiCl_4 + 2H$_2$O $\rightarrow$ SiO$_2$ + 4HCl **or**
SiCl_4 + 4H$_2$O $\rightarrow$ Si(OH)$_4$ + 4HCl **or**
SiCl_4 + 4H$_2$O $\rightarrow$ SiO$_2$.2H$_2$O + 4HCl (1) [5]

[Total: 16]

4 (a) (i) H$_2$X + 2NaOH $\rightarrow$ Na$_2$X + 2H$_2$O (1)

(ii) $n(OH^-) = \frac{21.6 \times 0.100}{1000} = 2.16 \times 10^{-3}$ mol (1)

(iii) $n(\mathbf{R}) = n(H_2X) = \frac{2.16 \times 10^{-3}}{2}$
$= 1.08 \times 10^{-3}$ mol in 25.0 cm^3 (1)

(iv) $n(\mathbf{R}) = 1.08 \times 10^{-3} \times \frac{250}{25.0} = 0.0108$ mol in 250 cm^3 (1)

(v) 0.0108 mol of **R** = 1.25 g of **R**
1 mol of **R** $= \frac{1.25 \times 1}{0.0108} = 115.7 = 116$ g (1) [5]

(b) (i) M_r of **S** = 116
M_r of **T** = 134
M_r of **U** = 150 **all three** needed (1)

(ii) **S** (1) [2]

(c) **S** into **T**
conc. H_2SO_4 **followed by** H_2O
or H_3PO_4 **followed by** H_2O **or**
steam **and** H_3PO_4 catalyst (1 + 1)

S into **U**
$KMnO_4$ (1)
cold dilute acidified **or** cold dilute alkaline (1)

T into **S**
P_4O_{10} **or conc.** H_2SO_4 **or** conc. H_3PO_4 **or** Al_2O_3
and heat in each case (1) [5]

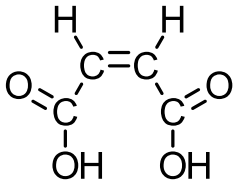
(d) **T** reacting with an excess of Na

$NaO_2CCH(ONa)CH_2CO_2Na$ (1)

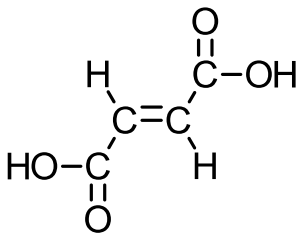
U reacting with an excess of Na_2CO_3

$NaO_2CCH(OH)CH(OH)CO_2Na$ (1) [2]

(e)



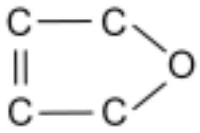
cis **or** Z



trans **or** E

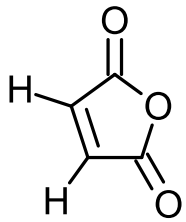
two correct structures (1)
correct labels (1) [2]

(f) correct ring of C and O atoms, i.e.



(1)

correct compound, i.e.



(1) [2]

(hydrogen atoms do not need to be shown)

[Total: 18]

5 (a) (i) alkanes **or** paraffins **not** hydrocarbons (1)

(ii) $\mathbf{2}C_4H_{10} + \mathbf{13}O_2 \rightarrow \mathbf{8}CO_2 + \mathbf{10}H_2O$ (1) [2]

(b) (i) **carbon** allow graphite (1)

(ii) $\mathbf{2}C_4H_{10} + \mathbf{5}O_2 \rightarrow \mathbf{8}C + \mathbf{10}H_2O$
allow balanced equations which include CO and/or CO_2 (1) [2]

(c) enthalpy change when 1 mol of a substance (1)
is burnt in an excess of oxygen/air under standard conditions
or is completely combusted under standard conditions (1) [2]

(d) (i) $m = \frac{pVM_r}{RT} = \frac{1.01\times10^5 \times 125\times10^{-6} \times 44}{8.31\times293}$ g (1)

= 0.228147345 g
= 0.23 g (1)

(ii) heat released = m c δ T = 200 × 4.18 × 13.8 J (1)
= 11536.8 J = 11.5 kJ (1)

(iii) 0.23 g of propane produce 11.5 kJ
44 g of propane produce $\frac{11.5\times44}{0.23}$ kJ
= 2200 kJ mol^{-1} (1) [5]

(e) (i) from methane to butane
there are more electrons in the molecule (1)
therefore greater/stronger van der Waals' forces (1)

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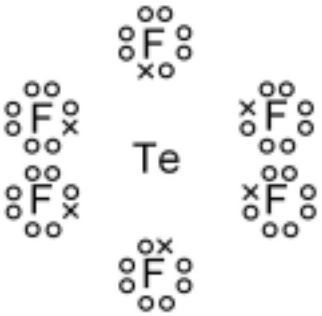

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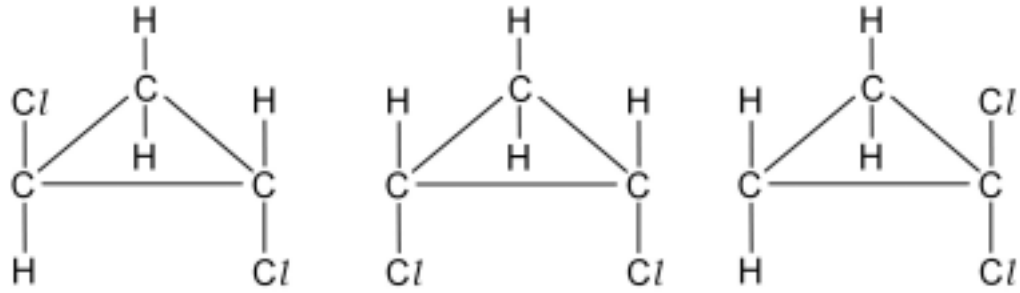

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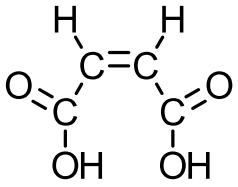

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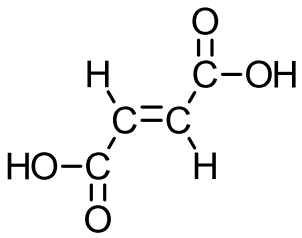

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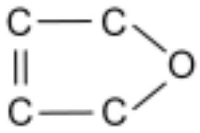

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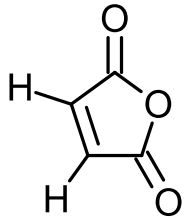

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(e) (i) from methane to butane
there are more electrons in the molecule (1)
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therefore stronger van der Waals' forces (1)
or reverse argument [4]

[Total: 15]

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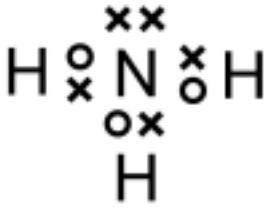
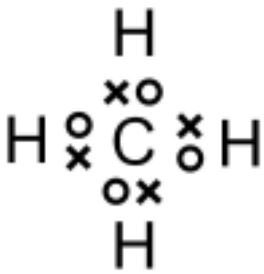
1 (a)

NH_3	CH_4
	
pyramidal	tetrahedral

both 'dot-and-cross' diagrams correct (1)
NH_3 is pyramidal **or** trigonal pyramidal (1)
CH_4 is tetrahedral (1) [3]

(b) (i) nitrogen and hydrogen have different electronegativities (1)
N–H bond has a dipole **or**
$N^{\delta-}—H^{\delta+}$ **or**
bonding pair is unequally shared (1)

(ii) molecule is not symmetrical **or**
dipoles do not cancel out (1)

(iii) NH_3 has higher boiling point than expected from M_r value **or**
has higher boiling point than methane
or NH_3 is soluble in water (1) [4]

(c) three covalent N–H bonds (1)
one co-ordinate (dative covalent) N–H bond (1)
one ionic bond between NH_4^+ and Cl^- (1) [3]

[Total: 10]

2 (a) (i) alkanes **or** paraffins **not** hydrocarbons (1)

(ii) **1**C_9H_{20} + **14**O_2 → **9**CO_2 + **10**H_2O (1) [2]

(b) (i) carbon (1)
carbon monoxide (1)
(names required)

(ii) CO is toxic **or** affects or combines with haemoglobin
or carbon causes respiratory problems (1)

(iii) **2**$C_{14}H_{30}$ + **15**O_2 → **28**C + **30**H_2O **or**

2$C_{14}H_{30}$ + **29**O_2 → **28**CO + **30**H_2O

or other balanced equations such as

$C_{14}H_{30}$ + **11**O_2 → **7**C + 7CO + **15**H_20

$C_{14}H_{30}$ + **18**O_2 → **7**CO + 7CO_2 + **15**H_20 (1) [4]

(c) enthalpy change when 1 mol of a substance (1)
is burnt in an excess of oxygen/air under standard conditions
or is completely combusted under standard conditions (1) [2]

(d) working **must** be shown

(i) heat released = m c δT = 250 × 4.18 × 34.6 (1)
= 36157 J = 36.2 kJ (1)

(ii) M_r of $C_{14}H_{30}$ = 198 (1)
mass of $C_{14}H_{30}$ = 1.00 × 0.763 = 0.763 g (1)
0.763 g of $C_{14}H_{30}$ produce 36.2 kJ
198 g of $C_{14}H_{30}$ produce $\frac{36.2 \times 198}{0.763}$
= 9394 kJ mol^{-1} (1) [5]

[Total: 13]

3 (a) (i)

halogen	melting point/°C	colour
chlorine	-101	green, yellow **or** greenish-yellow
bromine	-7	orange **or** red **or** brown
iodine	114	grey **accept** black

chlorine and bromine **both** correct (1)
iodine correct **for solid** (1)

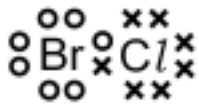
(ii) down the Group
there are more electrons in the molecule (1)
hence stronger van der Waals' forces (1) [4]

(b) (i)

chlorine	$1s^2 2s^2 2p^6 3s^2 3p^5$
bromine	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^5$
or	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$

both needed (1)

(ii)



(1) [2]

(c) (i) gas **or** low boiling liquid (1)
BrCl has fewer electrons than Br_2 (1)
hence weaker van der Waals' forces (1)

(ii) accept colours in the range yellow, orange, red, brown (1) [4]

(d) (i) **initially** solution begins to turn yellow/brown (1)
after several minutes black/dark grey solid formed (1)

(ii) $Cl_2 + 2KI \rightarrow 2KCl + I_2$ (1)

(iii) $BrCl + 2KI \rightarrow KCl + KBr + I_2$ (1)

(iv) as oxidising agents (1) [5]

[Total: 15]

4 (a) (i) structural **or** functional group isomerism (1)

(ii) **R** primary alcohol **and** carboxylic acid – **not** 'acid' (1)
S primary alcohol **and** ester (1)
T primary alcohol **and** ester (1)

(iii) **with Na_2CO_3**
carboxylic acid (1)

(iv) **with Na**
alcohol **and** carboxylic acid (1) [6]

(b) (i) $n(CO_2) = \frac{24.0}{24000} = 0.001$ mol (1)

(ii) 0.002 mol of **Q** $\rightarrow$ 0.001 mol of CO_2
1 mol of **Q** $\rightarrow$ 0.5 mol of CO_2 (1) [2]

(c) (i) $n(H_2) = \frac{48.0}{24000} = 0.002$ mol (1)

(ii) 0.002 mol of **Q** $\rightarrow$ 0.002 mol of H_2
1 mol of **Q** $\rightarrow$ 1 mol of H_2 (1) [2]

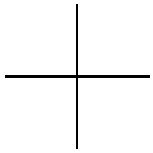
(d) **Q** is isomer **R** (1)

with sodium carbonate
$\mathbf{2}HOCH_2CH_2CO_2H + Na_2CO_3 \rightarrow \mathbf{2}\ HOCH_2CH_2CO_2Na + H_2O + CO_2$
correct products (1)
balanced (1)

with sodium metal
$HOCH_2CH_2CO_2H + \mathbf{2}Na \rightarrow NaOCH_2CH_2CO_2Na + H_2$
correct products (1)
balanced (1) [5]

[Total: 15]

5 (a)



(1) [1]

(b)

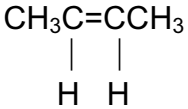
W	$CH_3CH_2CH_2CO_2H$
X	$CH_3CH_2COCH_3$
Y	$(CH_3)_2CHCO_2H$
Z	no reaction

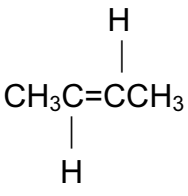
(4 × 1) [4]

(c) alcohol is **X** (no mark for this)

products are

$CH_3CH_2CH=CH_2$





(any two) [2]

[Total: 7]