

MARK SCHEME for the October/November 2013 series

9701 CHEMISTRY

9701/21

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

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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Page 2	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – October/November 2013	9701	21

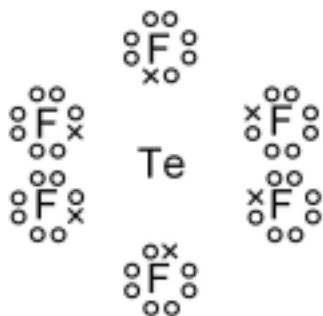
1 (a)

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 ₂ O 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]

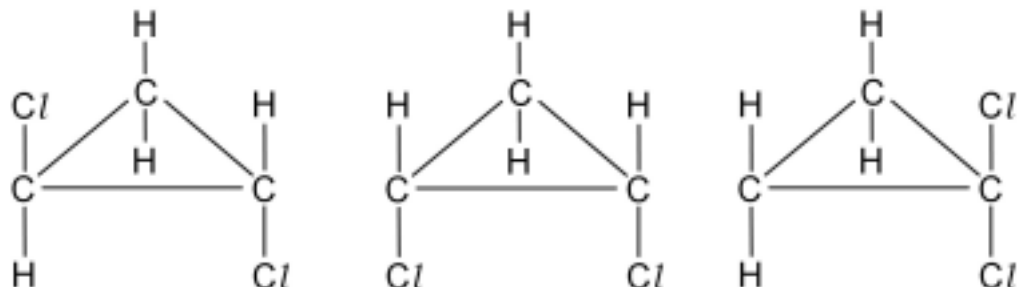
[Total: 6]

Page 3	Mark Scheme	Syllabus	Paper
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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** $\text{Cl}^-(\text{aq}) \rightarrow \frac{1}{2} \text{Cl}_2(\text{g}) + \text{e}^-$ (1)

cathode $\text{H}^+(\text{aq}) + \text{e}^- \rightarrow \frac{1}{2} \text{H}_2(\text{g})$ **or**
 $2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$ (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)

$2\text{Na} + \text{Cl}_2 \rightarrow 2\text{NaCl}$ (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)

$\text{P} + 2\frac{1}{2}\text{Cl}_2 \rightarrow \text{PCl}_5$ **or** $\text{P}_4 + 10\text{Cl}_2 \rightarrow 4\text{PCl}_5$

or

$\text{P} + 1\frac{1}{2}\text{Cl}_2 \rightarrow \text{PCl}_3$ **or** $\text{P}_4 + 6\text{Cl}_2 \rightarrow 4\text{PCl}_3$

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

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(c) cold dilute aqueous NaOH

NaOCl (1)
+1 (1)

hot concentrated aqueous NaOH

NaClO₃ (1)
+5 (1) [4]

(d) MgCl₂ 6.5 to 6.9 (1)

SiCl₄ 0 to 3 (1)

MgCl₂ dissolves without reaction **or**
slight **or** partial hydrolysis occurs (1)

SiCl₄ reacts with water **or**
hydrolysis occurs (1)

SiCl₄ + 2H₂O → SiO₂ + 4HCl **or**
SiCl₄ + 4H₂O → Si(OH)₄ + 4HCl **or**
SiCl₄ + 4H₂O → SiO₂·2H₂O + 4HCl (1) [5]

[Total: 16]

4 (a) (i) H₂X + 2NaOH → Na₂X + 2H₂O (1)

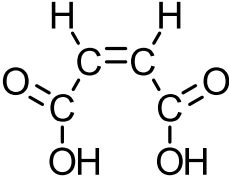
(ii) $n(\text{OH}^-) = \frac{21.6 \times 0.100}{1000} = 2.16 \times 10^{-3} \text{ mol}$ (1)

(iii) $n(\text{R}) = n(\text{H}_2\text{X}) = \frac{2.16 \times 10^{-3}}{2}$
 $= 1.08 \times 10^{-3} \text{ mol in } 25.0 \text{ cm}^3$ (1)

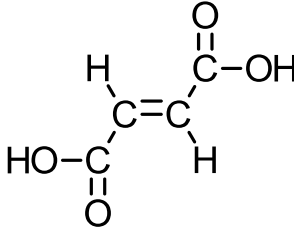
(iv) $n(\text{R}) = 1.08 \times 10^{-3} \times \frac{250}{25.0} = 0.0108 \text{ mol in } 250 \text{ cm}^3$ (1)

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

Page 5	Mark Scheme	Syllabus	Paper
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- (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
 $\text{NaO}_2\text{CCH(ONa)CH}_2\text{CO}_2\text{Na}$ (1)
- U** reacting with an excess of Na_2CO_3
 $\text{NaO}_2\text{CCH(OH)CH(OH)CO}_2\text{Na}$ (1) [2]
- (e)
- 

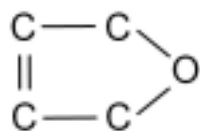
cis **or** *Z*



trans **or** *E*
- two correct structures (1)
 correct labels (1) [2]

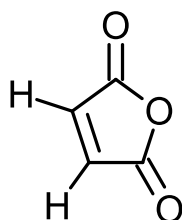
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(f) correct ring of C and O atoms, i.e.



(1)

correct compound, i.e.



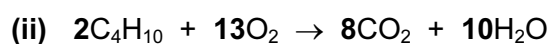
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(1) [2]

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

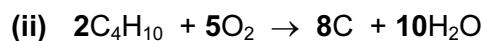
(1)



(1) [2]

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

(1)



allow balanced equations which include CO and/or CO_2

(1) [2]

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

(1)

(1) [2]

(d) (i) $m = \frac{pVM_r}{RT} = \frac{1.01 \times 10^5 \times 125 \times 10^{-6} \times 44}{8.31 \times 293} \text{ g}$

(1)

$$= 0.228147345 \text{ g}$$

$$= 0.23 \text{ g}$$

(1)

(ii) heat released = $m c \delta T = 200 \times 4.18 \times 13.8 \text{ J}$
= 11536.8 J = 11.5 kJ

(1)

(1)

(iii) 0.23 g of propane produce 11.5 kJ
44 g of propane produce $\frac{11.5 \times 44}{0.23} \text{ kJ}$
= 2200 kJ mol⁻¹

(1) [5]

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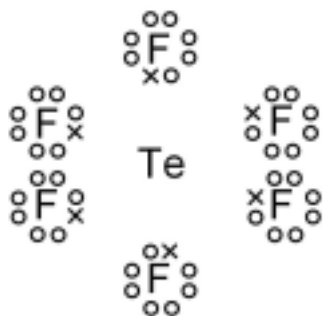
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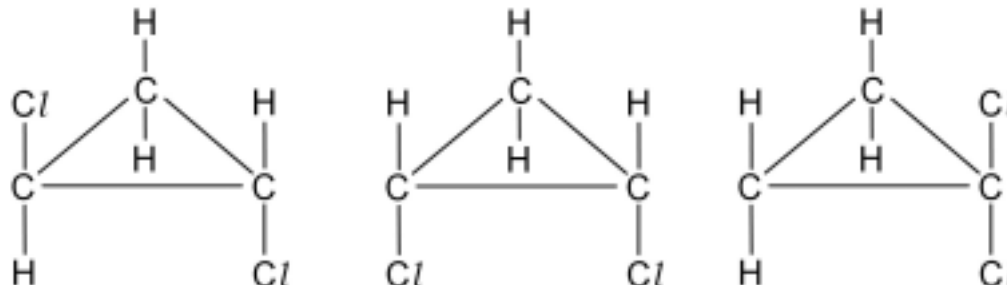
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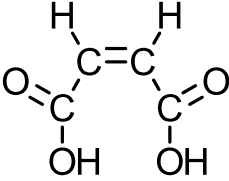
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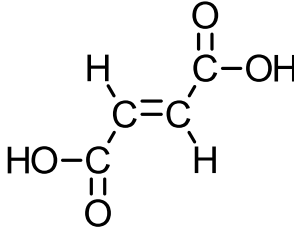
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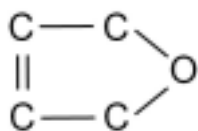
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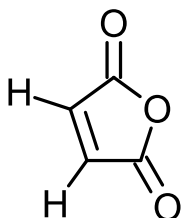
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(1)

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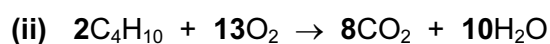
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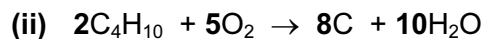
(1)



(1) [2]

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

(1)



allow balanced equations which include CO and/or CO₂

(1) [2]

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

(1)

(1) [2]

(d) (i) $m = \frac{pVM_r}{RT} = \frac{1.01 \times 10^5 \times 125 \times 10^{-6} \times 44}{8.31 \times 293} \text{ g}$

(1)

$$= 0.228147345 \text{ g}$$

$$= 0.23 \text{ g}$$

(1)

(ii) heat released = $m c \delta T = 200 \times 4.18 \times 13.8 \text{ J}$
= 11536.8 J = 11.5 kJ

(1)

(1)

(iii) 0.23 g of propane produce 11.5 kJ
44 g of propane produce $\frac{11.5 \times 44}{0.23} \text{ kJ}$
= 2200 kJ mol⁻¹

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- (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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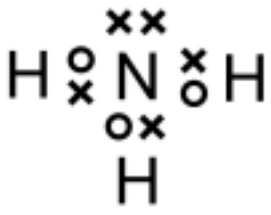
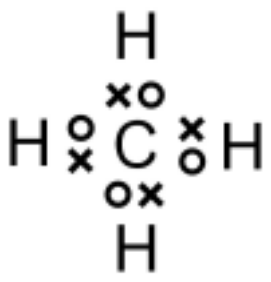
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1 (a)

NH_3 	CH_4 
pyramidal	tetrahedral

both 'dot-and-cross' diagrams correct
 NH_3 is pyramidal **or** trigonal pyramidal
 CH_4 is tetrahedral

(1)
(1)
(1) [3]

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

(1)

(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 $\text{N}-\text{H}$ bonds
one co-ordinate (dative covalent) $\text{N}-\text{H}$ bond
one ionic bond between NH_4^+ and Cl^-

(1)
(1)
(1) [3]

[Total: 10]

Page 3	Mark Scheme	Syllabus	Paper
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- 2 (a) (i) alkanes **or** paraffins **not** hydrocarbons (1)
- (ii) $1\text{C}_9\text{H}_{20} + 14\text{O}_2 \rightarrow 9\text{CO}_2 + 10\text{H}_2\text{O}$ (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) $2\text{C}_{14}\text{H}_{30} + 15\text{O}_2 \rightarrow 28\text{C} + 30\text{H}_2\text{O}$ **or**
 $2\text{C}_{14}\text{H}_{30} + 29\text{O}_2 \rightarrow 28\text{CO} + 30\text{H}_2\text{O}$
or other balanced equations such as
 $\text{C}_{14}\text{H}_{30} + 11\text{O}_2 \rightarrow 7\text{C} + 7\text{CO} + 15\text{H}_2\text{O}$
 $\text{C}_{14}\text{H}_{30} + 18\text{O}_2 \rightarrow 7\text{CO} + 7\text{CO}_2 + 15\text{H}_2\text{O}$ (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 = $m c \delta T = 250 \times 4.18 \times 34.6$ (1)
= 36157 J = 36.2 kJ (1)
- (ii) M_r of $\text{C}_{14}\text{H}_{30} = 198$ (1)
mass of $\text{C}_{14}\text{H}_{30} = 1.00 \times 0.763 = 0.763$ g (1)
0.763 g of $\text{C}_{14}\text{H}_{30}$ produce 36.2 kJ
198 g of $\text{C}_{14}\text{H}_{30}$ produce $\frac{36.2 \times 198}{0.763}$
= 9394 kJ mol⁻¹ (1) [5]

[Total: 13]

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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

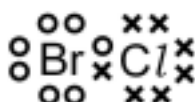
(1) [4]

(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) $\text{Cl}_2 + 2\text{KI} \rightarrow 2\text{KCl} + \text{I}_2$

(1)

(iii) $\text{BrCl} + 2\text{KI} \rightarrow \text{KCl} + \text{KBr} + \text{I}_2$

(1)

(iv) as oxidising agents

(1) [5]

[Total: 15]

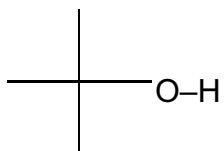
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- 4 (a) (i) structural **or** functional group isomerism (1)
- (ii) **R** primary alcohol **and** carboxylic acid – **not** 'acid' (1)
S primary alcohol **and** ester (1)
T primary alcohol **and** ester (1)
- (iii) **with Na₂CO₃**
carboxylic acid (1)
- (iv) **with Na**
alcohol **and** carboxylic acid (1) [6]
- (b) (i) $n(\text{CO}_2) = \frac{24.0}{24000} = 0.001 \text{ mol}$ (1)
- (ii) 0.002 mol of **Q** → 0.001 mol of CO₂
1 mol of **Q** → 0.5 mol of CO₂ (1) [2]
- (c) (i) $n(\text{H}_2) = \frac{48.0}{24000} = 0.002 \text{ mol}$ (1)
- (ii) 0.002 mol of **Q** → 0.002 mol of H₂
1 mol of **Q** → 1 mol of H₂ (1) [2]
- (d) **Q** is isomer **R** (1)
- with sodium carbonate**
 $2\text{HOCH}_2\text{CH}_2\text{CO}_2\text{H} + \text{Na}_2\text{CO}_3 \rightarrow 2\text{HOCH}_2\text{CH}_2\text{CO}_2\text{Na} + \text{H}_2\text{O} + \text{CO}_2$
correct products (1)
balanced (1)
- with sodium metal**
 $\text{HOCH}_2\text{CH}_2\text{CO}_2\text{H} + 2\text{Na} \rightarrow \text{NaOCH}_2\text{CH}_2\text{CO}_2\text{Na} + \text{H}_2$
correct products (1)
balanced (1) [5]

[Total: 15]

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5 (a)



(1) [1]

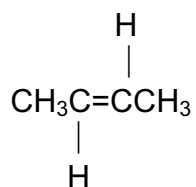
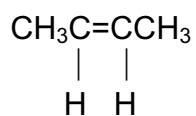
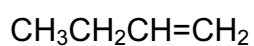
(b)

W	CH ₃ CH ₂ CH ₂ CO ₂ H
X	CH ₃ CH ₂ COCH ₃
Y	(CH ₃) ₂ CHCO ₂ H
Z	no reaction

(4 × 1) [4]

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

products are



(any two) [2]

[Total: 7]