

MARK SCHEME for the May/June 2012 question paper
for the guidance of teachers

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.

Mark schemes must be read in conjunction with the question papers and the report on the examination.

- Cambridge will not enter into discussions or correspondence in connection with these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2012 question papers for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level syllabuses and some Ordinary Level syllabuses.



Page 2	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9701	21

1 (a)

Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	P ₄ O ₁₀	SO ₂	Cl ₂ O ₇
alkaline	basic	amphoteric	acidic	acidic	acidic	acidic

Na₂O is alkaline – allow basic (1)

MgO is basic – allow alkaline (1)

Al₂O₃ is amphoteric (1)

SiO₂, P₄O₁₀, and SO₂ are **all** acidic (1) [4]

(b) any **two** from:
sodium, phosphorus, sulfur and chlorine
two names required (1) [1]

(c) (i) any **three** from:
floats
vigorous/violent reaction occurs
melts/forms a sphere
moves
disappears – allow dissolves
effervescence/gas produced (any 3)

(ii) Na + H₂O → NaOH + ½H₂
or
2Na + 2H₂O → 2NaOH + H₂ (1) [4]

(d) (i) combustion of fossil fuels – e.g. from car engines
from car exhausts **or**
during the extraction of metals from sulfide ores or
volcanic eruptions/burning sulfur from volcanoes or
burning biomass (1)

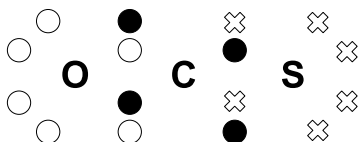
(ii) H₂SO₄
or
SO₃ allow H₂SO₃ **formula required** (1)

(iii) acid rain
or
its consequences e.g. damage to buildings,
damage to crops, plants, marine life
deforestation
or
SO₃ is toxic (1) [3]

(e) it is a reducing agent/antioxidant
or
it kills bacteria (1) [1]

Page 3	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9701	21

(f) (i)

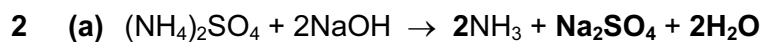


(1)

(ii) 180°

(1) [2]

[Total: 15]



correct products

(1)

correctly balanced equation

(1) [2]



(1)

(ii) $n(\text{HCl}) = \frac{31.2}{1000} \times 1.00 = 0.0312 = 0.03$

(1)

(iii) $n(\text{NaOH}) = \frac{50.0}{1000} \times 2.00 = 0.10$

(1)

(iv) $n(\text{NaOH}) \text{ used up} = 0.10 - 0.0312 = 0.0688 = 0.07$

(1)

(v) $n[(\text{NH}_4)_2\text{SO}_4] = \frac{0.0688}{2} = 0.0344 = 0.03$

(1)

(vi) $\text{mass of } (\text{NH}_4)_2\text{SO}_4 = 0.0344 \times 132 = 4.5408 = 4.54$

(1)

(vii) $\text{percentage purity} = \frac{4.5408 \times 100}{5.00} = 90.816 = 90.8$

(1) [7]

[Total: 9]

Page 4	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9701	21

- 3 (a) $\text{C(s)} + \text{O}_2\text{(g)} \rightarrow \text{CO}_2\text{(g)}$ (1)
the enthalpy change/energy change/heat change when
one mole of a compound/ CO_2 (1)
is formed from its elements in their standard states (1) [3]
- (b) (i)
$$\begin{array}{ccccccc} \Delta H_f^\circ/\text{kJ mol}^{-1} & \text{CO}_2\text{(g)} & + & 3\text{H}_2\text{(g)} & \rightleftharpoons & \text{CH}_3\text{OH(g)} & + & \text{H}_2\text{O(g)} \\ & -394 & & 0 & & -201 & & -242 \end{array}$$
- $\Delta H^\circ_{\text{reaction}} = -201 + (-242) - (-394)$ (1)
 -49 kJ mol^{-1} (1)
correct sign (1)
- (ii) removal of CO_2 from the atmosphere (1)
 CO_2 is a greenhouse gas/causes global warming (1) [5]
- (c) In this part, in each case, the 'effect' must be correctly stated
in order to gain the explanation mark.
- higher temperature**
yield is reduced/equilibrium goes to LHS (1)
because forward reaction is exothermic/reverse reaction is endothermic (1)
- higher pressure**
yield is increased **or** equilibrium goes to RHS (1)
fewer moles/molecules on RHS **or** more moles/molecules on LHS (1)
- use of catalyst**
yield does not change (1)
forward and backward rates speeded up by same amount (1) [6]

[Total: 14]

Page 5	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9701	21

- 4 (a) (i) $\text{C}_2\text{H}_5\text{OH} \rightarrow \text{C}_2\text{H}_4 + \text{H}_2\text{O}$ (1)
- (ii) elimination **or** dehydration (1)
- (iii) phosphoric acid **or** concentrated sulfuric acid
sulfuric acid must be 'concentrated'
allow aluminium oxide (1) [3]

(b)

	with HBr	with MnO_4^-
colour at start	colourless	purple or pink
colour after reaction	colourless	colourless or decolourised
structural formula of product	$\text{CH}_3\text{CH}_2\text{Br}$	$\text{HOCH}_2\text{CH}_2\text{OH}$

with hydrogen bromide

from colourless **to** colourless **both** colours required

do not allow 'clear' instead of colourless (1)

$\text{CH}_3\text{CH}_2\text{Br}$ (1)

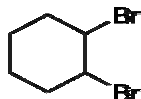
with potassium manganate(VII)

from purple/pink **to** colourless/decolourised **both** colours required (1)

$\text{HOCH}_2\text{CH}_2\text{OH}$ (1) [4]

- (c) (i) C_6H_{10} (1)

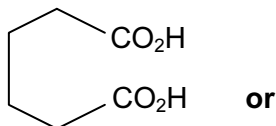
(ii)



accept answers which have $-\text{CH}_2-$ in the ring (1)

- (iii) electrophilic addition (1)
addition (1)

(iv)



$\text{HO}_2\text{C}(\text{CH}_2)_4\text{CO}_2\text{H}$ **or**

$\text{HO}_2\text{CCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$ (1)

accept answers which have $-\text{CH}_2-$ in the ring [5]

[Total: 12]

Page 6	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9701	21

5 (a) carboxylic acid **or** $\text{--CO}_2\text{H}$ **or** --COOH (1) [1]

(b) (i) alcohol (1)

(ii) $n(\text{H}_2) = \frac{160}{24000} = 6.67 \times 10^{-3} \text{ mol}$ (1)

$n(\text{H atoms}) = 2 \times 6.67 \times 10^{-3} \text{ mol} = 1.33 \times 10^{-2} \text{ mol}$ (1)

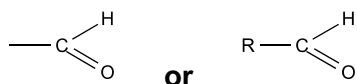
(iii) $n(\text{X}) = \frac{0.600}{90} = 6.67 \times 10^{-3} \text{ mol}$

$n(\text{X}) : n(\text{H atoms}) = 6.67 \times 10^{-3} : 1.33 \times 10^{-2}$
 $= 1 : 2$

since each --OH group produces one H atom
there are two --OH groups

(1) [4]

(c) (i)



(1)

(ii) $\text{HOCH}_2\text{CH}(\text{OH})\text{CHO}$ as the minimum
allow the *gem* diols $(\text{HO})_2\text{CHCH}_2\text{CHO}$ **or** $\text{CH}_3\text{C}(\text{OH})_2\text{CHO}$

(1)

(iii) $\text{HOCH}_2\text{CH}(\text{OH})\text{CO}_2\text{H}$ **or** $\text{HOCH}_2\text{CH}(\text{OH})\text{CO}_2^-$ (1) [3]

(d) (i) $\text{HOCH}_2\text{CH}(\text{OH})\text{CH}_2\text{OH}$ (1)

(ii) $\text{HO}_2\text{CCOCO}_2\text{H}$ (1) [2]

[Total: 10]

MARK SCHEME for the May/June 2012 question paper
for the guidance of teachers

9701 CHEMISTRY

9701/22

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.

Mark schemes must be read in conjunction with the question papers and the report on the examination.

- Cambridge will not enter into discussions or correspondence in connection with these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2012 question papers for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level syllabuses and some Ordinary Level syllabuses.



Page 2	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9701	22

- 1 (a) (i) silicon/Si **or** phosphorus/P (1)
- (ii) sodium **or** sulfur **name required** (1)
- (iii) white solid formed/white fumes seen
chlorine gas decolourised
aluminium glows **or** burns any two (2)
- (iv) $2Al(s) + 3Cl_2(g) \rightarrow Al_2Cl_6(s)$ **or**
 $2Al(s) + 3Cl_2(g) \rightarrow 2AlCl_3(s)$
equation (1)
state symbols (1)
- (v) outer shell of electrons is full/has a complete octet **or**
valence shell of electrons is full/has a complete octet **or**
activation energy is too high **or**
ionisation energy is too high (1) [7]

(b) (i)

element	Does the chloride dissolve or react?	approximate pH of the resulting solution
Na	dissolve	7
Al	react	1 to 4
Si	react	1 to 4

one mark for each correct answer (6 × 1)

- (ii) hydrolysis (1) [7]

- (c) (i) around the N atom there is only one lone pair
around the S atom there are two lone pairs **both** (1)

- (ii) angle (a) **or** sulfur – **no mark for this**

because two lone pairs repel more than one lone pair **or**
lone pair-lone pair repulsions are stronger
than lone pair-bond pair repulsions (1) [2]

[Total: 16]

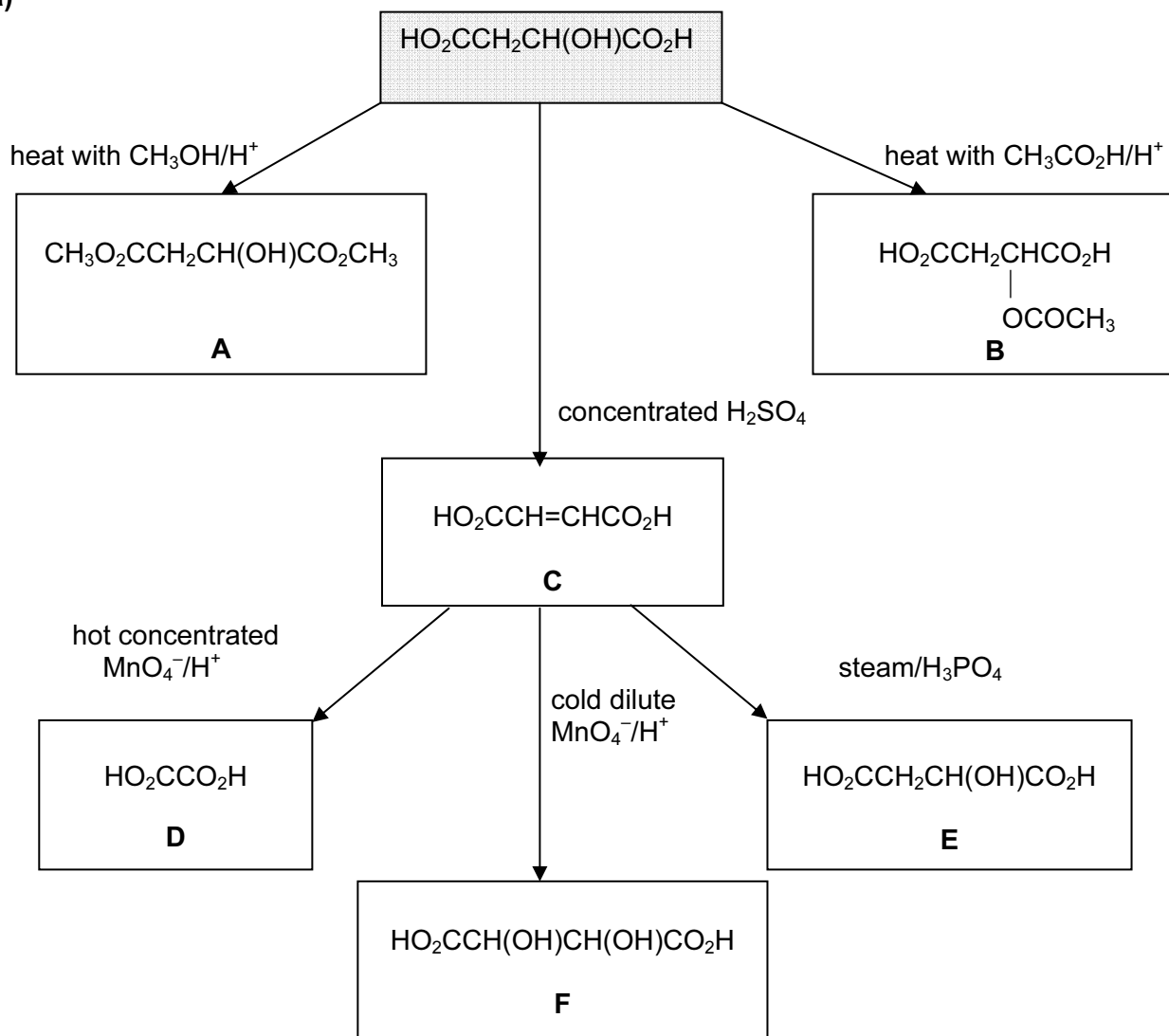
Page 3	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9701	22

- 2 (a) $\text{CH}_3\text{OH}(\text{l}) + \frac{3}{2}\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$ (1)
the enthalpy change/heat change/heat evolved when
one mole of CH_3OH (1)
is completely burned **or**
is burned in an excess of air/oxygen (1) [3]
- (b) $\Delta H^\ominus_{\text{reaction}} = -283 + 2(-286) - (-726)$ (1)
 $= -129 \text{ kJ mol}^{-1}$ (1)
correct sign (1) [3]
- (c) **pressure**
increases rate (1)
by increasing frequency of collisions **or**
by increasing concentration of reactants (1)
- temperature**
increases rate (1)
because more molecules have energy $>E_a$ (1)
- catalyst**
increases rate (1)
by providing an alternative route of lower E_a (1) [6]

[Total: 12]

Page 4	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9701	22

3 (a)



give one mark for each correct compound

(6 × 1) [6]

(b) malic acid into **C** dehydration **or** elimination

(1)

C into **D** oxidation

(1)

C into **E** addition **or** hydration

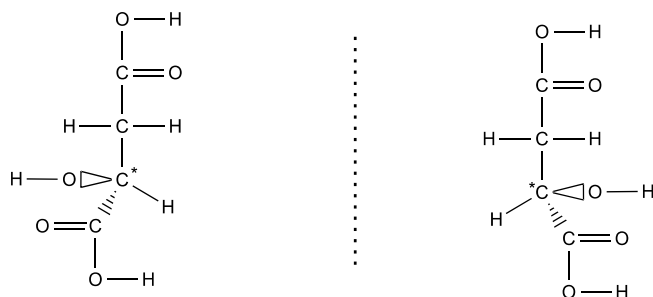
(1) [3]

(c) solvents **or** perfumes **or** flavourings

(1) [1]

Page 5	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9701	22

(d) (i)



correct compound (malic acid) shown as a pair of enantiomers in 3D

(1)

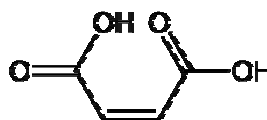
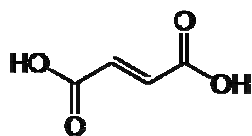
chiral carbon (*) atom correctly identified

(1)

structure **fully** displayed

(1)

(ii)



give one for each correct **skeletal formula**

(1 + 1)

correct *cis* (or *Z*) **and** *trans* (or *E*) labels

(1) [6]

(e) $C : H : O = \frac{37.5}{12} : \frac{4.17}{1} : \frac{58.3}{16}$

$= 3.13 : 4.17 : 3.64$

(1)

$= 1 : 1.33 : 1.16$

(1)

$= 6 : 8 : 7$

empirical formula is $C_6H_8O_7$

(1) [3]

[Total: 19]

Page 6	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9701	22

4 (a)

reagent	R ₂ CHOH	RCHO	RCO ₂ H	RCO ₂ R'	RCOR'
NaHCO ₃			✓		
Na	✓		✓		
Cr ₂ O ₇ ²⁻ /H ⁺	✓	✓			

give one mark for each correct tick

(5 × 1) [5]

- (b) (i) alcohol **or** ROH
not hydroxyl **or** phenol **or** –OH

(1)

(ii) $n(\text{H}_2) = \frac{80}{24000} = 3.3 \times 10^{-3} \text{ mol}$

(1)

$n(\text{H atoms}) = 2 \times 3.3 \times 10^{-3} \text{ mol} = 6.6 \times 10^{-3} \text{ mol}$

(1)

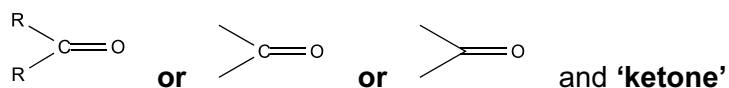
(iii) $n(\text{G}) = \frac{0.30}{90} = 3.3 \times 10^{-3} \text{ mol}$

$n(\text{G}) : n(\text{H atoms}) = 3.3 \times 10^{-3} : 6.6 \times 10^{-3}$
 $= 1 : 2$

so each –OH group produces one H atom

(1) [4]

(c) (i)



(1)

- (ii) **G** is HOCH₂COCH₂OH as the minimum
 allow the *gem* diol CH₃COCH(OH)₂

(1)

[2]

- (d) (i) **H** is HO₂CCOCO₂H as the minimum

(1)

- (ii) **J** is HOCH₂CH(OH)CH₂OH as the minimum

(1)

[2]

[Total: 13]

MARK SCHEME for the May/June 2012 question paper
for the guidance of teachers

9701 CHEMISTRY

9701/23

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.

Mark schemes must be read in conjunction with the question papers and the report on the examination.

- Cambridge will not enter into discussions or correspondence in connection with these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2012 question papers for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level syllabuses and some Ordinary Level syllabuses.



Page 2	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9701	23

- 1 (a) (i) **from Na to Cl**
- nuclear charge increases (1)
- electrons are in the same shell/have the same shielding (1)
- nuclear attraction increases (1)
- (ii) argon does not form any bonds/compounds **or** (1) [4]
- argon exists as single atoms/is monatomic

(b) (i)

radius of cation/nm			radius of anion/nm		
Na ⁺	Mg ²⁺	Al ³⁺	P ³⁻	S ²⁻	Cl ⁻
0.095	0.065	0.050	0.212	0.184	0.181

- (1)
- (ii) cations contain fewer electrons than the corresponding atoms **or** (1)
- cations contain fewer electrons than they do protons (1)
- nucleus has a greater attraction (1)
- (iii) anions contain more electrons than the corresponding atoms **or** (1)
- anions contain more electrons than they do protons (1) [5]
- nucleus has a smaller attraction
- (c) (i) $\text{Na}_2\text{O} + \text{H}_2\text{O} \rightarrow 2\text{NaOH}$ (1)
- $\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3$ (1)
- (ii) for Na₂O 10 to 14 (1)
- for SO₂ 1 to 4 (1)
- (iii) $\text{NaOH} + \text{H}_2\text{SO}_3 \rightarrow \text{NaHSO}_3 + \text{H}_2\text{O}$ **or** (1) [5]
- $2\text{NaOH} + \text{H}_2\text{SO}_3 \rightarrow \text{Na}_2\text{SO}_3 + 2\text{H}_2\text{O}$

[Total: 14]

Page 3	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9701	23

- 2 (a) (i) $\text{Na}_2\text{CO}_3 + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{H}_2\text{O} + \text{CO}_2$ (1)
- (ii) $n(\text{HCl}) = \frac{35.8}{1000} \times 0.100 = 3.58 \times 10^{-3}$ (1)
- (iii) $n(\text{Na}_2\text{CO}_3) = \frac{35.8}{2} \times 10^{-3} = 1.79 \times 10^{-3} \text{ mol in } 25.0 \text{ cm}^3$ (1)
- (iv) $n(\text{Na}_2\text{CO}_3) = 1.79 \times 10^{-3} \times 10 = 1.79 \times 10^{-2} \text{ mol in } 250 \text{ cm}^3$ (1)
- (v) mass of $\text{Na}_2\text{CO}_3 = 1.79 \times 10^{-2} \times 106 = 1.90 \text{ g}$
 M_r of $\text{Na}_2\text{CO}_3 = 106$ (1)
mass of $\text{Na}_2\text{CO}_3 = 1.90 \text{ g}$ (1) [6]
- (b) $n(\text{H}_2\text{O})$ in 5.13 g of washing soda = $\frac{5.13 - 1.90}{18} = 1.79 \times 10^{-1} \text{ mol}$ (1)
 $n(\text{Na}_2\text{CO}_3)$ in 5.13 g of washing soda = $1.79 \times 10^{-2} \text{ mol}$
 $n(\text{H}_2\text{O}) : n(\text{Na}_2\text{CO}_3) = 10 : 1$ (1)
- or
1.90 g Na_2CO_3 are combined with 3.23 g H_2O
106 g Na_2CO_3 are combined with $\frac{3.23 \times 106}{1.90} = 180.2 \text{ g H}_2\text{O}$ (1)
this is 10 mol of H_2O (1)
- or
 $1.79 \times 10^{-2} \text{ mol Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O} \equiv 5.13 \text{ g of washing soda}$
 $1 \text{ mol Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O} \equiv \frac{5.13}{1.79 \times 10^{-2}} = 286.6 \text{ g}$ (1)
 $\text{Na}_2\text{CO}_3 = 106$ and $\text{H}_2\text{O} = 18$ hence $x = 10$ (1) [2]

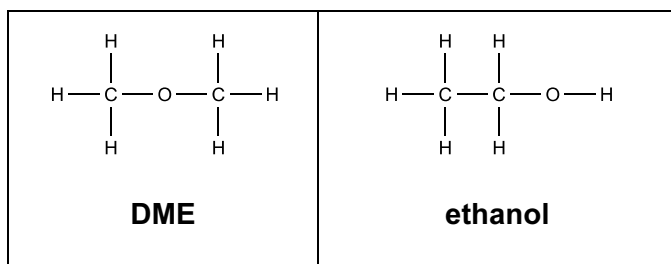
[Total: 8]

Page 4	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9701	23

- 3 (a) $\text{CH}_3\text{OCH}_3(\text{l}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\text{l})$ (1)
the enthalpy change/heat change/heat evolved when
one mole of CH_3OCH_3 /a compound (1)
is completely burned **or**
burned in an excess of air/oxygen (1) [3]

- (b)
$$\begin{array}{rclcl} 2\text{CH}_3\text{OH}(\text{l}) & \rightarrow & \text{CH}_3\text{OCH}_3(\text{g}) & + & \text{H}_2\text{O}(\text{l}) \\ \Delta H^\circ_{\text{f}}/\text{kJ mol}^{-1} & & -184 & & -286 \\ & & 2(-239) & & \\ \Delta H^\circ_{\text{reaction}} & = & -184 + (-286) - 2(-239) & & (1) \\ & = & +8 \text{ kJ mol}^{-1} & & (1) \\ \text{correct sign} & & & & (1) \end{array}$$
 [3]

- (c) (i)



both correct (1)

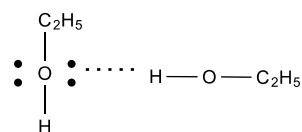
- (ii) structural isomerism **or** functional group isomerism (1) [2]

- (d) (i) hydrogen bonds (1)

- (ii) lone pair on O atom of $\text{C}_2\text{H}_5\text{OH}$ (1)

correct dipole $\text{O}^{\delta-}-\text{H}^{\delta+}$ on bond in one molecule of ethanol (1)

hydrogen bond shown between lone pair of an O atom and a hydrogen atom,
i.e.



(1) [4]

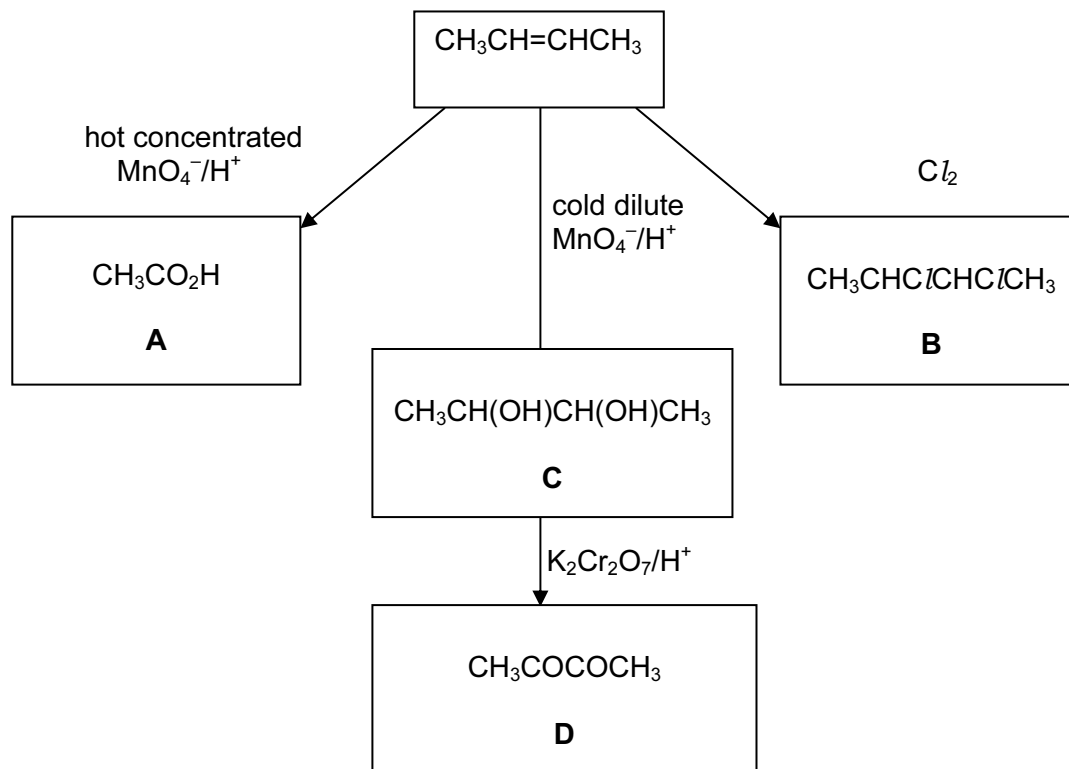
[Total: 12]

Page 5	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9701	23

- 4 (a) high temperature and high pressure (1)
 high temperature and catalyst (1) [2]

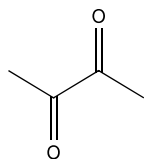
- (b) $C_{12}H_{26} \rightarrow C_4H_8 + C_8H_{18}$ or (1)
 $C_{12}H_{26} \rightarrow 2C_4H_8 + C_4H_{10}$ (1) [1]

(c)



(4 × 1) [4]

(d) (i)



(1)

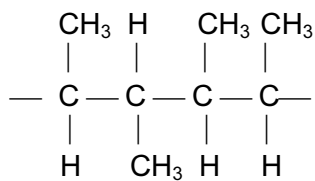
- (ii) compound **B**
 compound **C**

(1)

(1) [3]

Page 6	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9701	23

(e)



allow any orientation of CH₃– groups

(1) [1]

(f) (i) CH₂=CH—CH=CH₂

allow CH₃CHOHCH=CH₂ and CH₃C≡CCH₃

(1)

(ii) CH₂BrCHBrCHBrCH₂Br

allow CH₃CBr₂CBr₂CH₃ from CH₃CHOHCH=CH₂

allow CH₃CHOHCHBrCH₂Br from CH₃C≡CCH₃

(1)

(iii) electrophilic addition

both words required

(1) [3]

[Total: 14]

Page 7	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9701	23

- 5 (a) (i) CO₂/carbon dioxide (1)
- (ii) carboxylic acid **or** –CO₂H **or** –COOH (1) [2]

- (b) (i) dehydration **or** elimination (1)
- (ii) H contains >C=C< bond (1)
H contains –CO₂H group (1)
H is CH₂=CHCO₂H (1) [4]

- (c) $n(\text{F}) = \frac{0.600}{90} = 6.67 \times 10^{-3} \text{ mol}$ (1)
- F contains one –OH group and one –CO₂H group (1)
hence one mole of F produces one mole of H₂ with Na (1)
 $n(\text{H}_2) = 6.67 \times 10^{-3} \text{ mol}$ (1)
vol. of H₂ = $6.67 \times 10^{-3} \times 24000 \text{ cm}^3$ (1)
= 160 cm³ at room temperature and pressure (1) [4]

(d) (i)

HOCH ₂ CH ₂ CO ₂ H	CH ₃ CH(OH)CO ₂ H
J	K

one isomer correct (1)

(ii)

HO ₂ CCH ₂ CO ₂ H	CH ₃ COCO ₂ H
product from J	product from K

one oxidation product correct (1) [2]

[Total: 12]