

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS GCE Advanced Subsidiary Level and GCE Advanced Level

## MARK SCHEME for the May/June 2011 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 2011 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 2011	9701	21	
1	(a)	alka <b>not</b>	anes/j hydr	oaraffins ocarbon		(1)	[1]
	(b)	<b>2</b> C	$_{14}H_{30}$	+ 43 $O_2 \rightarrow$ 28 $CO_2$ + 30 $H_2O$ or			
		C <sub>14</sub>	H <sub>30</sub> +	$^{43}/_{2}O_{2} \rightarrow 14 \text{ CO}_{2} + 15 \text{ H}_{2}O$		(1)	[1]
	(c)	(i)	mas	s of C <sub>14</sub> H <sub>30</sub> burnt			
			<u>8195</u> 1	<u>5 x 10.8</u> = 88.506 = 88.5 t 000		(1)	
		(ii)	mas	s of CO <sub>2</sub> produced			
			<i>M</i> <sub>r</sub> o	$f C_{14}H_{30} = (14 \times 12 + 30 \times 1) = 198$		(1)	
			2 x 1	98 t of $C_{14}H_{30} \rightarrow 28 \text{ x } 44 \text{ t of } CO_2$			
			88.5	t of $C_{14}H_{30} \rightarrow \frac{28 \times 44 \times 88.5}{2 \times 198}$		(1)	
			= 27	5.3 t of CO <sub>2</sub>		(1)	
			allov allov	v 275.4 t if candidate has used 88.506 v ecf on wrong value for $M_{\rm r}$ of $C_{14}H_{30}$			[4]
	(d)	n =	<u> PV</u> =	$= \frac{6 \times 10^5 \times 710 \times 10^{-6}}{2.21 \times 202}$		(1)	
		=	0.17	5 0.31 X 293		(1)	[2]
	(e)	P =	<u>nRT</u> V	= <u>0.175 x 8.31 x 278</u> 710 x 10 <sup>-6</sup>		(1)	
		=	5694	10.5634 Pa = 5.7 x 10 <sup>5</sup>		(1)	
		allo	w ecf	on <b>(d)</b>			[2]
						[Total:	10]

Page 3			Mark Scheme: Teachers' version	Syllabus	Paper	
			GCE AS/A LEVEL – May/June 2011	9701	21	
2 (a)	(i)	brea brea	k large hydrocarbons into smaller hydrocarbons <b>or</b> k down large hydrocarbons		(1)	
		sma sma	ller hydrocarbons are more useful <b>or</b> ller hydrocarbons are more in demand		(1)	
	(ii)	usin usin	g high temperatures/thermal cracking <b>or</b> g catalysts/catalytic cracking		(1)	
	(iii)	C <sub>14</sub> H C <sub>14</sub> H C <sub>14</sub> H C <sub>14</sub> H do n	$H_{30} \rightarrow C_7 H_{16} + C_7 H_{14}$ or $H_{30} \rightarrow C_7 H_{16} + C_2 H_4 + C_5 H_{10}$ or $H_{30} \rightarrow C_7 H_{16} + C_3 H_6 + C_4 H_8$ or $H_{30} \rightarrow C_7 H_{16} + 2C_2 H_4 + C_3 H_6$ ot allow any equation with $H_2$		(1)	[4]
(b)	eth	anol ł	nas hydrogen bonding, ethanethiol does not		(1)	[1]
(c)	(i)	C <sub>2</sub> H 2C <sub>2</sub> H corre	$_{5}SH + {}^{9}I_{2}O_{2} \rightarrow 2CO_{2} + SO_{2} + 3H_{2}O \text{ or}$ $H_{5}SH + 9O_{2} \rightarrow 4CO_{2} + 2SO_{2} + 6H_{2}O$ ect products ect equation which is balanced		(1) (1)	
	(ii)	for ( enha glob	CO₂ anced greenhouse effect al warming		(1) (1)	
		for s form dam disse dam	<b>SO<sub>2</sub></b> ation of acid rain age to stonework of buildings/ olving of aluminium ions into rivers/ age to watercourses or forests/		(1)	
		aqua corre	atic life destroyed/ osion of metals		(1)	[6]
(d)	hel	p dete	ect leaks of gas		(1)	[1]
(e)	terr pre V <sub>2</sub> C	nperat ssure D₅/var	ture of 450°C of 1 – 2 atm nadium(V) oxide/vanadium pentoxide catalyst		(1) (1) (1)	[3]
					[Total:	15]

Page 4			Mark Scheme: Teachers' version			Syllabus		Paper		
			GCE AS/A LEVEL – May/June 2011			9701		21		
3	U( Ca	aq) I <b>C I</b> 2	dilute H		Ca(s)	(I)	in air H <sub>2</sub> O(I)	V ( Ca	(s) <b>0</b> dilute HNO <sub>3</sub>	
	C	Y(s) aCO₃	CO₃(aq)		X(s) Ca(OH) <sub>2</sub> dilute H <sub>2</sub> SO <sub>4</sub> Z(s) CaSO <sub>4</sub>		reaction	W(a Ca(N	aq)   <b>O<sub>3</sub>)</b> 2	
(8	i) L V V )	) / / /	CaC $l_2$ CaO Ca(NO <sub>3</sub> ) <sub>2</sub> Ca(OH) <sub>2</sub> CaCO <sub>3</sub>						(1) (1) (1) (1) (1)	[5]
(1	) hea do r	t stror not alle	ngly in a test-tube or ow 'heat gently' or 're	a boiling ti eflux'	ube				(1)	[1]
(0	;) (i)	Ca to Ca +	<b>U</b> 2HC $l \rightarrow CaCl_2 + H_2$						(1)	
		CaO	+ 2HNO <sub>3</sub> $\rightarrow$ Ca(NO	9 <sub>3</sub> ) <sub>2</sub> + H <sub>2</sub> O					(1)	
		U to ` CaC <i>l</i>	$\mathbf{Y}_2 + Na_2CO_3 \to CaCO_3$	⊃₃ + 2NaC	1				(1)	
	(ii)	2Ca(	$NO_3)_2 \rightarrow 2CaO + 4N$	IO <sub>2</sub> + O <sub>2</sub>					(1)	[4]

(d)  $Na_2SO_4(aq)/K_2SO_4(aq)$  or formula of any soluble sulfate (1) [1]

	Page	5 Mark Scheme: Teachers' version	Syllabus 9701	Paper 21	
	(e) (i)	Ca to <b>X</b> colourless gas formed/fizzing/effervescence/bubbl Ca dissolves <b>or</b> white precipitate/suspension formed	es or	(1)	
	(ii)	strongly exothermic/vigorous reaction <b>or</b> steam formed/steamy fumes <b>or</b> surface crumbles do not allow white ppt.		(1)	[2]
				[Total:	13]
4	(a) (i)	nucleophilic addition <b>both</b> words are necessary		(1)	
	(ii)	NaCN and H₂SO₄ <b>or</b> HCN plus CN <sup>−</sup> do not allow HCN on its own		(1)	
	(iii)	correct $\delta$ + and $\delta$ -, i.e.		(1)	[3]
	(b) (i)	correct organic product			
		$(CH_3)_2C \longrightarrow NH \longrightarrow NO_2$			
		C=N bond must be clearly shown H <sub>2</sub> O formed/ equation balanced		(1) (1)	[2]
	(ii)	H <sub>3</sub> C、			

(1) [1]

[Total: 6]

Page	6	Mark Scheme: Teachers' version	Syllabus	Paper	
		GCE AS/A LEVEL – May/June 2011	9701	21	
<b>(a)</b> Ca	C <sub>2</sub> +	$2H_2O \rightarrow Ca(OH)_2 + C_2H_2$		(1)	[1]
(b) (i)	step	1 electrophilic		(1)	
	step	2 elimination <b>or</b> dehydrohalogenation		(1)	
(ii)	reag	ent NaOH/KOH/OH <sup>-</sup>		(1)	
	only	allow conditions mark if reagent is correct		(1)	[5]
(c) (i)	<b>Q</b> is <b>R</b> is	$CH_3CHO$ ( as minimum) $CH_3CO_2H$ (as minimum)		(1) (1)	
(ii)	step step	3 is addition 4 is oxidation/redox		(1) (1)	[4]
(d) (i)	com C <sub>2</sub> H equa H <sub>2</sub> C	<b>abustion</b> $_{2}(g) + {}^{5}/_{2}O_{2}(g) \rightarrow 2CO_{2}(g) + H_{2}O(I)$ or ation must be for the combustion of one mole of C <sub>2</sub> H <sub>2</sub> ) must be shown as liquid pect state symbols in this equation		(1) (1)	
	<b>forn</b> 2C(៖ no n	hation s) + $H_2(g) \rightarrow C_2H_2(g)$ hark for state symbols here		(1)	
(ii)	let 2	<b>Z</b> be $\Delta H^{e}_{f}$ of C <sub>2</sub> H <sub>2</sub>			
		$C_2H_2 + {}^{5}\!/_2O_2 \rightarrow 2CO_2 + H_2O$			
	∆H <sup>e</sup> ∧ <i>H</i> e	z = -1300 = 2(-394) + (-286) - Z		(1)	
	whe	nce $\mathbf{Z} = 2(-394) + (-286) - (-1300)$		(')	
	= +2 valu sign allov	26 kJ mol <sup>-1</sup> e v ecf on wrong equation		(1) (1)	[6]
	Page (   (a) Ca   (b) (i)   (c) (i)   (c) (i)   (d) (i)   (ii) (ii)	Page 6(a) $CaC_2 + (i)$ (b) (i) step(i) (i) step(ii) reag(ii) reag(ii) (ii) Q is(c) (i) Q is(ii) step(ii) step(ii) step(ii) (ii) com(c) (i) Q is(ii) let 2(ii) let 2 $\Delta H^e_{fl}$ <t< td=""><td>Page 6Mark Scheme: Teachers' version GCE AS/A LEVEL – May/June 2011(a) <math>CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2</math>(b) (i) step 1electrophilic addition step 2(ii) reagentNaOH/KOH/OHT conditions in alcohol/ethanol only allow conditions mark if reagent is correct(c) (i) Q is CH_3CHO ( as minimum) R is CH_3CO_2H (as minimum)(ii) step 3 is addition step 4 is oxidation/redox(d) (i) combustion <math>C_2H_2(g) + {}^{9}I_2O_2(g) \rightarrow 2CO_2(g) + H_2O(l)</math> or equation must be for the combustion of one mole of <math>C_2H_2</math> <math>H_2O</math> must be shown as liquid correct state symbols in this equationformation <math>2C(s) + H_2(g) \rightarrow C_2H_2(g)</math> no mark for state symbols here(ii) let Z be <math>\Delta H^{\theta}_1</math> of <math>C_2H_2</math> <math>C_2H_2 + {}^{5}I_2O_2 \rightarrow 2CO_2 + H_2O</math> <math>\Delta H^{\theta}_1 = X = 0</math> <math>2(-394) + (-286) - Z</math> whence Z = 2(-394) + (-286) - Z whence Z = 2(-394) + (-286) - (-1300) <math>= +226</math> kJ mol<sup>-1</sup> value sign allow ecf on wrong equation</td><td>Page 6Mark Scheme: Teachers' versionSyllabusGCE AS/A LEVEL – May/June 20119701(a) <math>CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2</math>(b) (i) step 1electrophilic addition step 2step 1electrophilic addition on dehydrohalogenation(ii) reagentNaOH/KOH/OHT conditions in alcohol/ethanol only allow conditions mark if reagent is correct(c) (i) Q is CH<sub>3</sub>CHO ( as minimum) R is CH<sub>3</sub>CO<sub>2</sub>H (as minimum)(ii) step 3 is addition step 4 is oxidation/redox(d) (i) combustion <math>C_2H_2(g) + \frac{5}{2}O_2(g) \rightarrow 2CO_2(g) + H_2O(l)</math> or equation must be for the combustion of one mole of <math>C_2H_2</math> <math>H_2O</math> must be shown as liquid correct state symbols in this equationformation <math>2C(s) + H_2(g) \rightarrow C_2H_2(g)</math> no mark for state symbols here(ii) let Z be <math>\Delta H^{0}_{r}</math> of <math>C_2H_2</math> <math>C_2H_2 + \frac{5}{2}O_2 \rightarrow 2CO_2 + H_2O</math> <math>\Delta H^{0}_{c} = -1300 = 2(-394) + (-286) - Z</math> whence <math>Z = 2(-394) + (-286) - Z</math> whence <math>Z = 2(-394) + (-286) - Z</math> whence <math>Z = 2(-394) + (-286) - (-1300)</math> <math>= +226</math> kJ mol<sup>-1</sup> value sign allow ecf on wrong equation</br></br></br></td><td>Page 6   Mark Scheme: Teachers' version   Syllabus   Paper     GCE AS/A LEVEL - May/June 2011   9701   21     (a) CaC<sub>2</sub> + 2H<sub>2</sub>O → Ca(OH)<sub>2</sub> + C<sub>2</sub>H<sub>2</sub>   (1)     (b) (i) step 1   electrophilic addition   (1)     (a) CaC<sub>2</sub> + 2H<sub>2</sub>O → Ca(OH)<sub>2</sub> + C<sub>2</sub>H<sub>2</sub>   (1)     (b) (i) step 1   electrophilic addition   (1)     (ii) reagent   NaOH/KOH/OH<sup>-</sup> conditions in alcohol/ethanol   (1)     (ii) reagent   NaOH/KOH/OH<sup>-</sup> conditions mark if reagent is correct   (1)     (c) (i) Q is CH<sub>3</sub>CHO (as minimum)   (1)   (1)     (ii) step 3 is addition step 4 is oxidation/redox   (1)     (d) (i) combustion C<sub>2</sub>H<sub>2</sub>(g) → f<sub>1</sub>C<sub>3</sub>(g) → 2CO<sub>2</sub>(g) + H<sub>2</sub>O(l) or equation must be for the combustion of one mole of C<sub>2</sub>H<sub>2</sub> H<sub>2</sub>O must be shown as liquid correct state symbols in this equation   (1)     (ii) let Z be ΔH<sup>2</sup> r of C<sub>2</sub>H<sub>2</sub> C<sub>2</sub>(H<sub>2</sub> + <sup>5</sup>/<sub>2</sub>O<sub>2</sub> → 2CO<sub>2</sub> + H<sub>2</sub>O ΔH<sup>2</sup> r   (1)     (iii) let Z be ΔH<sup>2</sup> r of C<sub>2</sub>H<sub>2</sub>   (1)     whence Z = 2(-394) + (-286) - Z   (1)     whence Z = 2(-394) + (-286) - (-1300)   (1)     = +226 kJ mol<sup>-1</sup> value   (1)     allow ecf on wrong equation   (1)</td></t<>	Page 6Mark Scheme: Teachers' version GCE AS/A LEVEL – May/June 2011(a) $CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$ (b) (i) step 1electrophilic addition step 2(ii) reagentNaOH/KOH/OHT conditions in alcohol/ethanol only allow conditions mark if reagent is correct(c) (i) Q is CH_3CHO ( as minimum) R is CH_3CO_2H (as minimum)(ii) step 3 is addition step 4 is oxidation/redox(d) (i) combustion $C_2H_2(g) + {}^{9}I_2O_2(g) \rightarrow 2CO_2(g) + H_2O(l)$ or equation must be for the combustion of one mole of $C_2H_2$ $H_2O$ must be shown as liquid correct state symbols in this equationformation $2C(s) + H_2(g) \rightarrow C_2H_2(g)$ no mark for state symbols here(ii) let Z be $\Delta H^{\theta}_1$ of $C_2H_2$ $C_2H_2 + {}^{5}I_2O_2 \rightarrow 2CO_2 + H_2O$ $\Delta H^{\theta}_1 = X = 0$ $2(-394) + (-286) - Z$ whence Z = 2(-394) + (-286) - Z whence Z = 2(-394) + (-286) - (-1300) $= +226$ kJ mol <sup>-1</sup> value sign allow ecf on wrong equation	Page 6Mark Scheme: Teachers' versionSyllabusGCE AS/A LEVEL – May/June 20119701(a) $CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$ (b) (i) step 1electrophilic addition step 2step 1electrophilic addition on dehydrohalogenation(ii) reagentNaOH/KOH/OHT conditions in alcohol/ethanol only allow conditions mark if reagent is correct(c) (i) Q is CH <sub>3</sub> CHO ( as minimum) R is CH <sub>3</sub> CO <sub>2</sub> H (as minimum)(ii) step 3 is addition step 4 is oxidation/redox(d) (i) combustion $C_2H_2(g) + \frac{5}{2}O_2(g) \rightarrow 2CO_2(g) + H_2O(l)$ or 	Page 6   Mark Scheme: Teachers' version   Syllabus   Paper     GCE AS/A LEVEL - May/June 2011   9701   21     (a) CaC <sub>2</sub> + 2H <sub>2</sub> O → Ca(OH) <sub>2</sub> + C <sub>2</sub> H <sub>2</sub> (1)     (b) (i) step 1   electrophilic addition   (1)     (a) CaC <sub>2</sub> + 2H <sub>2</sub> O → Ca(OH) <sub>2</sub> + C <sub>2</sub> H <sub>2</sub> (1)     (b) (i) step 1   electrophilic addition   (1)     (ii) reagent   NaOH/KOH/OH <sup>-</sup> conditions in alcohol/ethanol   (1)     (ii) reagent   NaOH/KOH/OH <sup>-</sup> conditions mark if reagent is correct   (1)     (c) (i) Q is CH <sub>3</sub> CHO (as minimum)   (1)   (1)     (ii) step 3 is addition step 4 is oxidation/redox   (1)     (d) (i) combustion C <sub>2</sub> H <sub>2</sub> (g) → f <sub>1</sub> C <sub>3</sub> (g) → 2CO <sub>2</sub> (g) + H <sub>2</sub> O(l) or equation must be for the combustion of one mole of C <sub>2</sub> H <sub>2</sub> H <sub>2</sub> O must be shown as liquid correct state symbols in this equation   (1)     (ii) let Z be ΔH <sup>2</sup> r of C <sub>2</sub> H <sub>2</sub> C <sub>2</sub> (H <sub>2</sub> + <sup>5</sup> / <sub>2</sub> O <sub>2</sub> → 2CO <sub>2</sub> + H <sub>2</sub> O ΔH <sup>2</sup> r   (1)     (iii) let Z be ΔH <sup>2</sup> r of C <sub>2</sub> H <sub>2</sub> (1)     whence Z = 2(-394) + (-286) - Z   (1)     whence Z = 2(-394) + (-286) - (-1300)   (1)     = +226 kJ mol <sup>-1</sup> value   (1)     allow ecf on wrong equation   (1)

[Total: 16]