

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

**MARK SCHEME for the October/November 2009 question paper  
for the guidance of teachers**

**9701 CHEMISTRY**

**9701/21**

Paper 21 (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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- 1 (a) same proton number/atomic number (1)  
different mass number/nucleon number (1) [2]

(b)  $A_r = \frac{(24 \times 78.60) + (25 \times 10.11) + (26 \times 11.29)}{100}$  (1)

$$= \frac{1886.4 + 252.75 + 293.54}{100} = \frac{2432.69}{100}$$

which gives  $A_r = 24.33$  (1)  
penalise (–1) for misuse of significant figures [2]

(c)

isotopes	number of		
	protons	neutrons	electrons
$^{226}\text{Ra}$	88	138	88
$^{238}\text{U}$	92	146	92

allow **one mark** for each correct column (3 × 1)  
if there are no correct columns,  
allow **maximum one mark** for a correct row [3]

(d) (i)  $\text{Ra}^{2+}$  (1)

(ii) less than (502 + 966)  
allow answers in the range 1000–1400 kJ mol<sup>–1</sup> (1)

ionisation energies decrease down the Group  
**or** must be less than IE for Ba → Ba<sup>2+</sup>  
**or** size of atom increases down Group/  
electrons are further away from nucleus  
**or** there is increased shielding down Group (1)

allow ecf on answer to (i) [3]

[Total: 10]

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- 2 (a) (i) configuration ends in  $s^2$   
or there are two electrons in outermost/valence shell (1)
- (ii)  $\text{RaCO}_3$ /radium carbonate (1) [2]
- (b) anode  $\text{Br}^- \rightarrow \frac{1}{2}\text{Br}_2 + \text{e}^-$  (1)  
cathode  $\text{Ra}^{2+} + 2\text{e}^- \rightarrow \text{Ra}$  (1) [2]
- (c) (i) **water** slow reaction  
gas bubbles  
gas is colourless any 2 (2)
- steam** Mg glows  
vigorous reaction  
white solid formed any 2 (2)
- (ii)  $\text{Mg} + \text{H}_2\text{O} \rightarrow \text{MgO} + \text{H}_2$  (1) [5]
- (d) (i)  $\text{Ra(s)} + 2\text{H}_2\text{O(l)} \rightarrow \text{Ra(OH)}_2\text{(aq)} + \text{H}_2\text{(g)}$  eqn. (1)  
s.s. (1)
- (ii) radium dissolves/disappears  
gas evolved  
gas is colourless  
heat evolved any 2 (2)
- (iii) 10–14 (1)
- (iv) more – **no mark for this alone**  
**because** reactivity of metals increases down the Group  
**or** electrons are further from nucleus  
**or** IE is lower  
**or** Ra is a stronger reducing agent (1) [6]

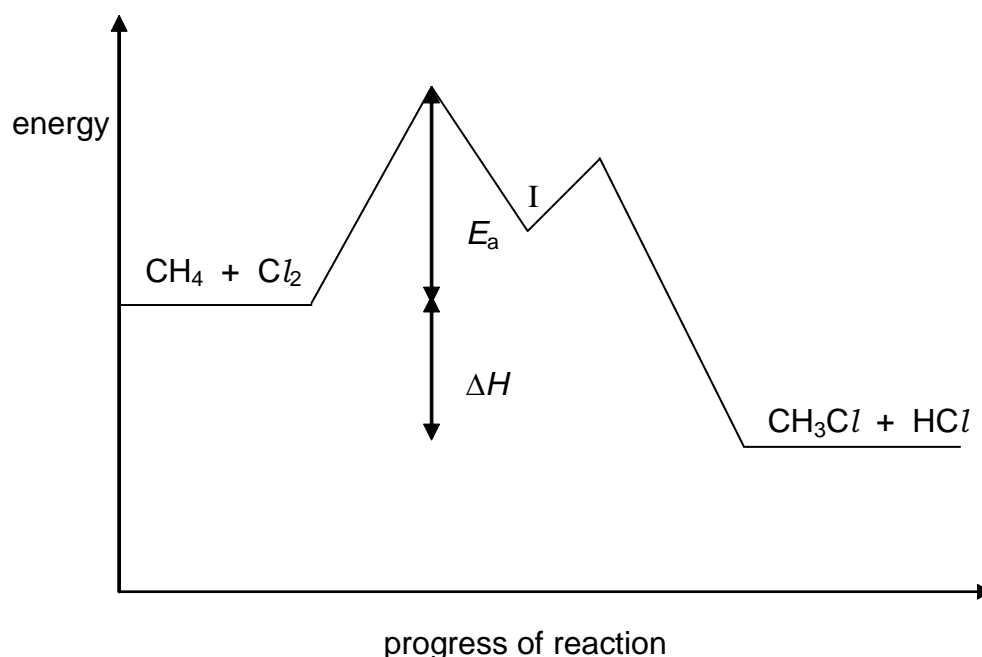
[Total: 15]

Page 4	Mark Scheme: Teachers' version	Syllabus	Paper
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- 3 (a) (i)  $\text{CH}_4 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{HCl}$   
 $\Delta H_f^\circ$       -75                  0                  -82                  -92                  (1)
- $\Delta H^\circ_{\text{reaction}} = -82 + (-92) - (-75)$   
 $= -99 \text{ kJ mol}^{-1}$  (1)
- (ii)  $\text{CH}_4 + \text{I}_2 \rightarrow \text{CH}_3\text{I} + \text{HI}$   
 broken C-H                  I-I      made C-I                  H-I  
 410                  151                  240                  299 (1)
- $\Delta H^\circ_{\text{reaction}} = -240 + (-299) + 410 + 151$   
 $= +22 \text{ kJ mol}^{-1}$  (1)
- (iii) activation energy is too great (1) [5]
- (b) (i) initiation (1)  
 $\text{Cl}_2 + \text{uvl} \rightarrow 2\text{Cl}$  (1)  
 propagation (1)
- $\text{CH}_4 + \text{Cl} \rightarrow \text{CH}_3 + \text{HCl}$   
 $\text{CH}_3 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{Cl}$  both needed (1)
- termination (1)
- $\text{CH}_3 + \text{CH}_3 \rightarrow \text{C}_2\text{H}_6$  or  
 $\text{CH}_3 + \text{Cl} \rightarrow \text{CH}_3\text{Cl}$  or
- $\text{Cl} + \text{Cl} \rightarrow \text{Cl}_2$  (1)
- (ii)  $\text{CH}_3$ /methyl radical (1) [7]

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(c)



- correct placement of 16 kJ (1)
- correct placement of –99 kJ (allow ecf on wrong calculation in (a) (i)) (1)
- intermediate clearly shown at I (1)
- correct 'double peak' shape (1)
- second peak lower than first (1) [5]

[Total: max 16]

Page 6	Mark Scheme: Teachers' version	Syllabus	Paper
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4 (a) (i)  $C_2H_5O$  (1)

(ii)  (1)

(iii)

compound	type of isomerism
<b>A</b>	<i>cis-trans</i> or geometrical
<b>D</b>	optical

allow one mark if **both A and D** are correctly identified  
but in **both** cases, the type of isomerism is incorrect

(1 + 1) [4]

(b) (i) dehydration/elimination (1)

(ii) conc.  $H_2SO_4/P_4O_{10}/Al_2O_3$ /pumice etc. (1)

(iii)  $CH_2=CHCH=CH_2$ /butadiene/buta-1,3-diene (1) [3]

(c) (i)  $CH_3CH_2CH(OH)CH_3$  (1)

(ii) steam with  $H_3PO_4$  catalyst or  
conc.  $H_2SO_4$  then water (1 + 1)

(iii)  $Cr_2O_7^{2-}/H^+$  (1) [4]

(d) functional group isomerism  
or structural isomerism  
not positional isomerism (1) [1]

[Total: 12]

Page 7	Mark Scheme: Teachers' version	Syllabus	Paper
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5 (a) G is HCHO/methanal (1) [1]

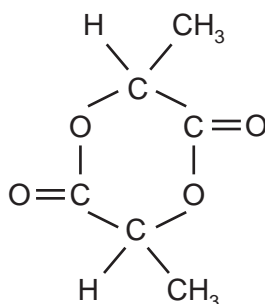
(b) (i) carboxylic acid/carboxyl/–CO<sub>2</sub>H  
not acid (1)

(ii) H is CH<sub>3</sub>CO<sub>2</sub>H/ethanoic acid (1)

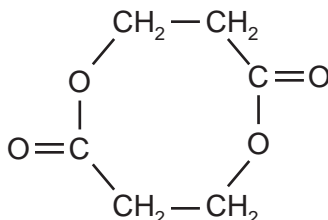
(iii) J is CH<sub>3</sub>CH(OH)CO<sub>2</sub>H/2-hydroxypropanoic acid  
allow HOCH<sub>2</sub>CH<sub>2</sub>CO<sub>2</sub>H/3-hydroxypropanoic acid (1) [3]

(c) K is CH<sub>3</sub>COCO<sub>2</sub>H (1) [1]

(d) (i) L is



allow as ecf on HOCH<sub>2</sub>CH<sub>2</sub>CO<sub>2</sub>H/3-hydroxypropanoic acid



(1)

(ii) esterification (1)  
allow elimination/dehydration/condensation [2]

[Total: 7]