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

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1 **(a)** same proton number/atomic number (1)
different mass number/nucleon number (1) [2]

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

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

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

(c)

isotopes	number of		
	protons	neutrons	electrons
^{226}Ra	88	138	88
^{238}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)** Ra^{2+} (1)

(ii) less than (502 + 966)
allow answers in the range 1000–1400 kJ mol^{-1} (1)

ionisation energies decrease down the Group
or must be less than IE for $Ba \rightarrow Ba^{2+}$
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) $RaCO_3$/radium carbonate (1) [2]

(b) anode $Br^- \rightarrow \frac{1}{2}Br_2 + e^-$ (1)
cathode $Ra^{2+} + 2e^- \rightarrow Ra$ (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) $Mg + H_2O \rightarrow MgO + H_2$ (1) [5]

(d) (i) $Ra(s) + 2H_2O(l) \rightarrow Ra(OH)_2(aq) + H_2(g)$ 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]

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3 (a) (i)

	CH_4	+	Cl_2	→	CH_3Cl	+	HCl
$\Delta H_f^\ominus$	–75		0		–82		–92

(1)

$\Delta H^\ominus_{reaction}$ = –82 + (–92) – (–75)
= –99 kJ mol^{-1} (1)

(ii)

	CH_4	+	I_2	→	CH_3I	+	HI
broken	C–H		I–I	made	C–I		H–I
	410		151		240		299

(1)

$\Delta H^\ominus_{reaction}$ = –240 + (–299) + 410 + 151
= +22 kJ mol^{-1} (1)

(iii) activation energy is too great (1) [5]

(b) (i) initiation (1)

Cl_2 + uvl → 2Cl (1)

propagation (1)

$CH_4 + Cl \rightarrow CH_3 + HCl$
$CH_3 + Cl_2 \rightarrow CH_3Cl + Cl$ both needed (1)

termination (1)

$CH_3 + CH_3 \rightarrow C_2H_6$ **or**
$CH_3 + Cl \rightarrow CH_3Cl$ **or**

$Cl + Cl \rightarrow Cl_2$ (1)

(ii) CH_3/methyl radical (1) [7]

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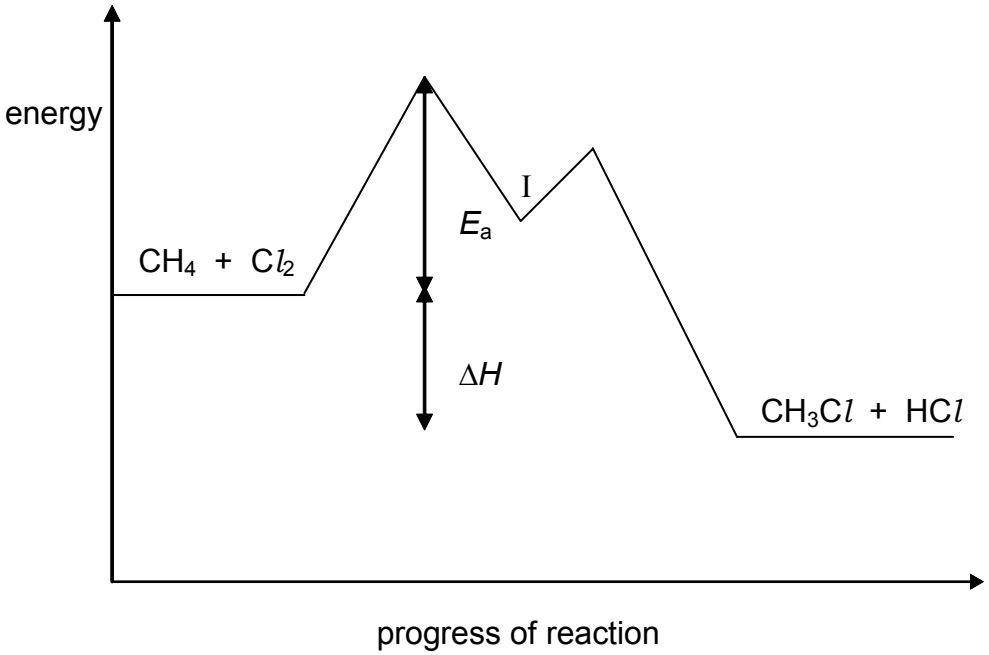
(c)



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]

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4 (a) (i) C_2H_5O (1)

(ii) 

(1)

(iii)

compound	type of isomerism
A	*cis-trans* **or** geometrical
D	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]

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5 **(a)** **G** is HCHO/methanal (1) [1]

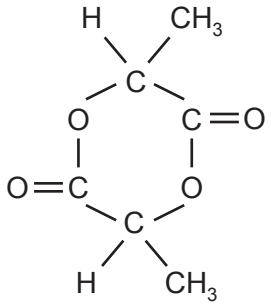
(b) **(i)** carboxylic acid/carboxyl/–CO_2H
not acid (1)

(ii) **H** is CH_3CO_2H/ethanoic acid (1)

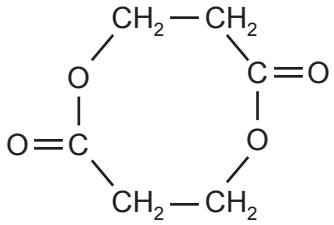
(iii) **J** is $CH_3CH(OH)CO_2H$/2-hydroxypropanoic acid
allow $HOCH_2CH_2CO_2H$/3-hydroxypropanoic acid (1) [3]

(c) **K** is CH_3COCO_2H (1) [1]

(d) **(i)** **L** is



allow as ecf on $HOCH_2CH_2CO_2H$/3-hydroxypropanoic acid



(1)

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

[Total: 7]

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