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.

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

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

CIE is publishing the mark schemes for the October/November 2009 question papers for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level syllabuses and some Ordinary Level syllabuses.

UNIVERSITY of CAMBRIDGE
International Examinations

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]

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]

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)

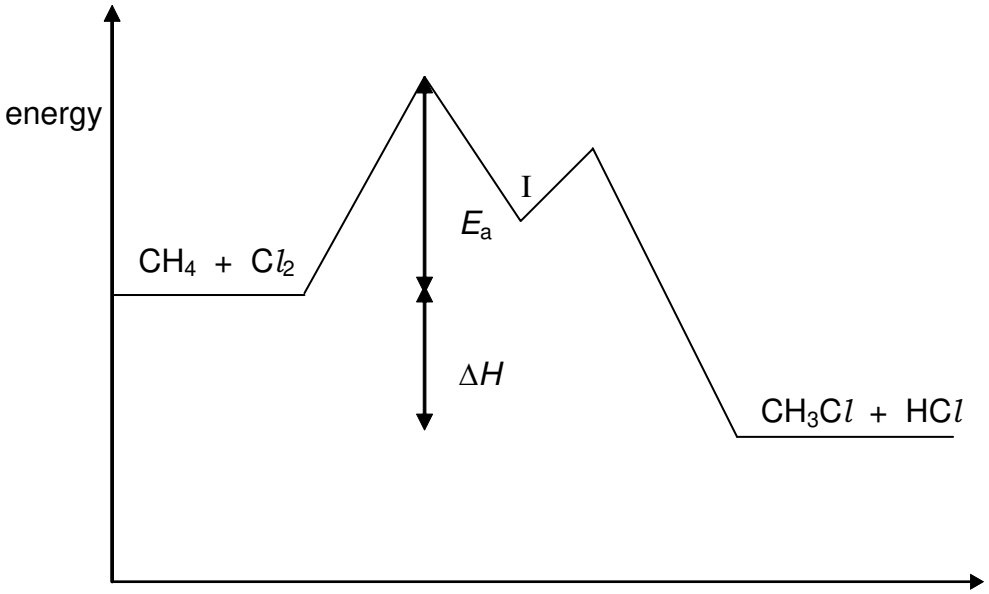
termination (1)

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

$Cl + Cl \rightarrow Cl_2$ (1)

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

(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]

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]

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

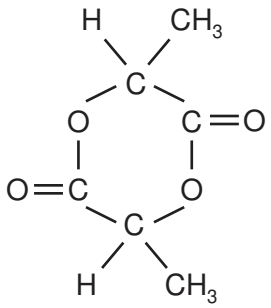
(b) (i) carboxylic acid/carboxyl/–CO_2H
not acid (1)

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

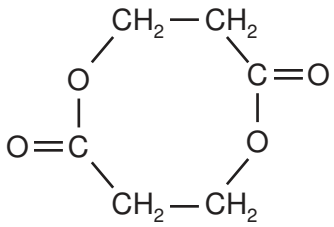
(iii) **J** is $CH_3CH(OH)CO_2H$/2-hydroxypropanoic acid
allow $HOCH_2CH_2CO_2H$/3-hydroxypropanoic acid (1) [3]

(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]