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

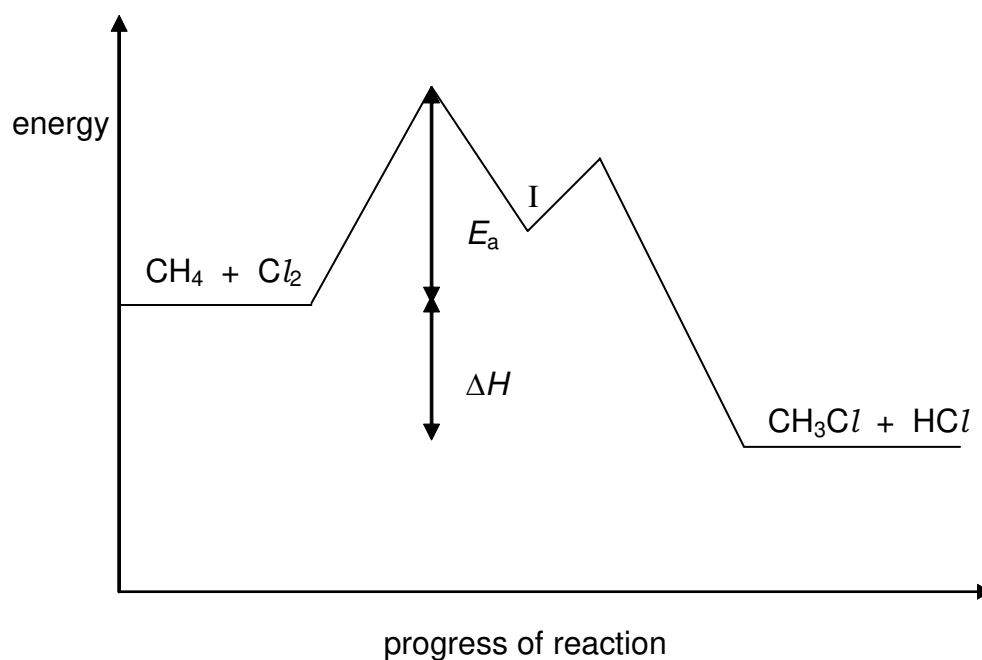allow ecf on answer to **(i)** [3]

[**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)

$$CH_4 \quad + \quad Cl_2 \quad \rightarrow \quad CH_3Cl \quad + \quad HCl$$

$\Delta H_f^{\ominus}$ –75   0   –82   –92   (1)

$\Delta H^{\ominus}_{reaction}$ = –82 + (–92) – (–75)

           = –99 kJ mol^{-1} (1)

(ii)

$$CH_4 \quad + \quad I_2 \quad \rightarrow \quad CH_3I \quad + \quad HI$$

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 $\rightarrow$ 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)

$$\text{energy}$$

$CH_4 + Cl_2$

E_a

I

ΔH

$CH_3Cl + HCl$

progress of reaction

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
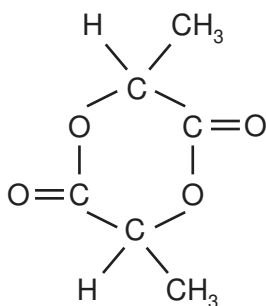
          allow as ecf on $HOCH_2CH_2CO_2H$/3-hydroxypropanoic acid
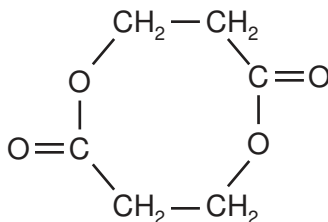
          (1)

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

[Total: 7]