

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}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) (1)
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 → Ba²⁺
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 $\text{Br}^- \rightarrow \frac{1}{2}\text{Br}_2 + \text{e}^-$ (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]

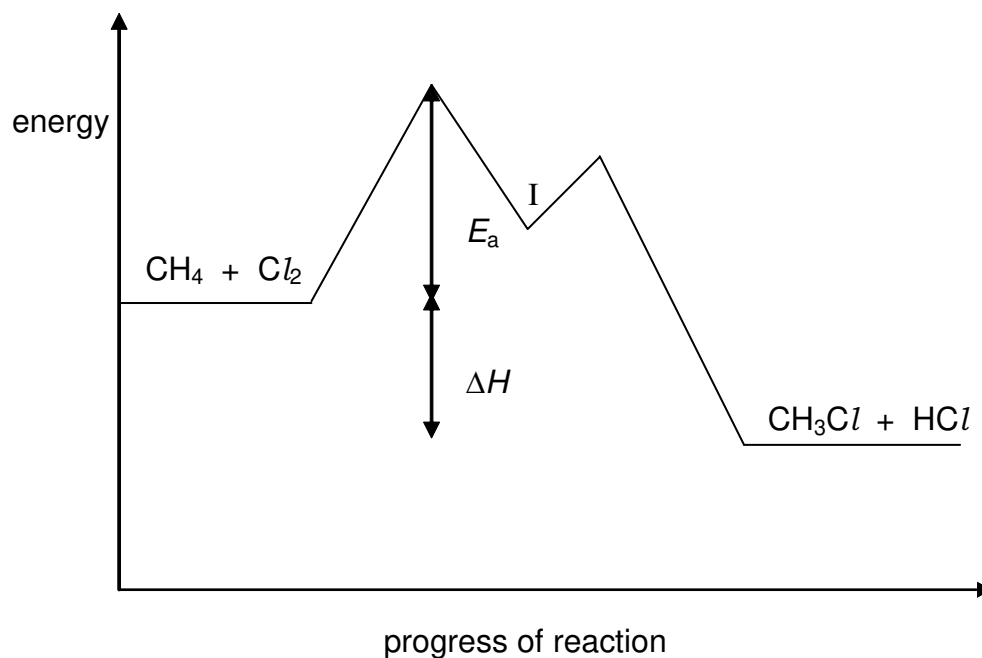
[Total: 15]

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- 3 (a) (i)
- | | | | | | | | | |
|----------------------|---------------|---|---------------|---------------|------------------------|---|--------------|-----|
| | CH_4 | + | Cl_2 | \rightarrow | CH_3Cl | + | HCl | |
| ΔH_f^\ominus | -75 | | 0 | | -82 | | -92 | (1) |
- $\Delta H^\ominus_{\text{reaction}} = -82 + (-92) - (-75)$
 $= -99 \text{ kJ mol}^{-1}$ (1)
- (ii)
- | | | | | | | | | |
|--------|---------------|---|--------------|---------------|-----------------------|---|-------------|-----|
| | CH_4 | + | I_2 | \rightarrow | CH_3I | + | HI | |
| broken | C-H | | I-I | made | C-I | | H-I | |
| | 410 | | 151 | | 240 | | 299 | (1) |
- $\Delta H^\ominus_{\text{reaction}} = -240 + (-299) + 410 + 151$
 $= +22 \text{ kJ mol}^{-1}$ (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) 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 | <i>cis-trans</i> 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]

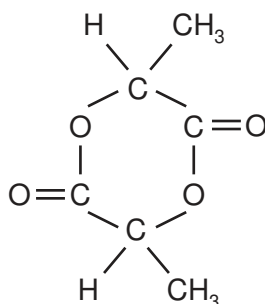
(b) (i) carboxylic acid/carboxyl/-CO₂H
not acid (1)

(ii) H is CH₃CO₂H/ethanoic acid (1)

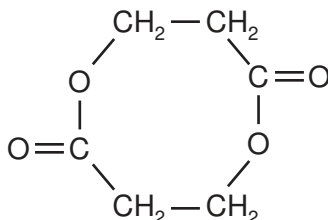
(iii) J is CH₃CH(OH)CO₂H/2-hydroxypropanoic acid
allow HOCH₂CH₂CO₂H/3-hydroxypropanoic acid (1) [3]

(c) K is CH₃COCO₂H (1) [1]

(d) (i) L is



allow as ecf on HOCH₂CH₂CO₂H/3-hydroxypropanoic acid



(1)

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

[Total: 7]