

**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) $A_r = \frac{(24 \times 78.60) + (25 \times 10.11) + (26 \times 11.29)}{100}$ (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)
allow answers in the range 1000–1400 kJ mol^{–1} (1)

ionisation energies decrease down the Group
or must be less than IE for $\text{Ba} \rightarrow \text{Ba}^{2+}$
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 $\text{Br}^- \rightarrow \frac{1}{2}\text{Br}_2 + \text{e}^-$ (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]

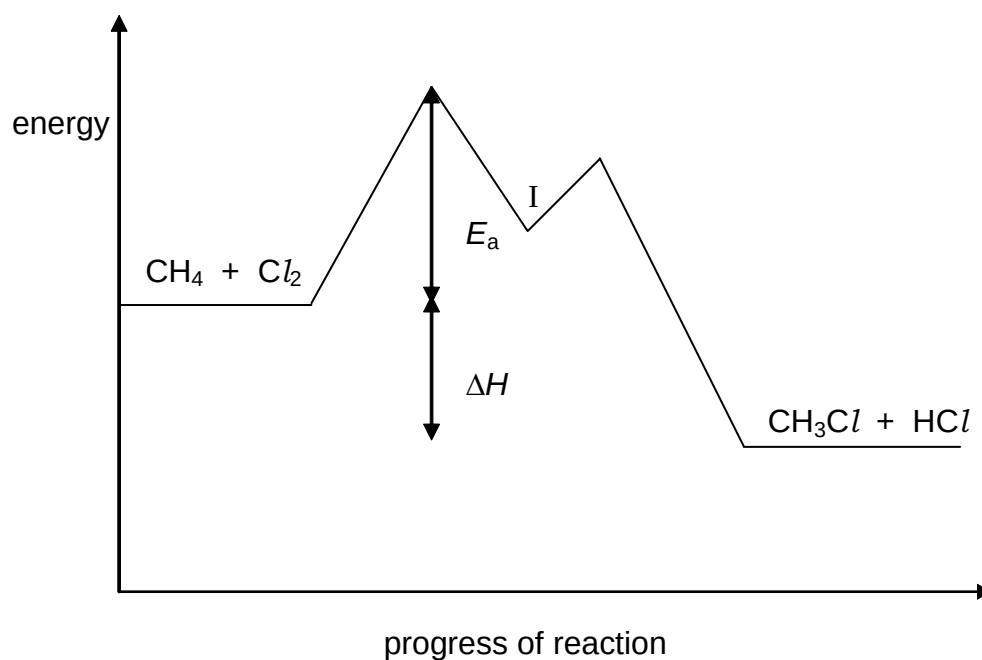
[Total: 15]

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- 3 (a) (i)
- | | | | | | | | | |
|--------------------|---------------|---|---------------|---------------|------------------------|---|--------------|-----|
| ΔH_f° | CH_4 | + | Cl_2 | $\rightarrow$ | CH_3Cl | + | HCl | |
| | -75 | | 0 | | -82 | | -92 | (1) |
- $$\Delta H^\circ_{\text{reaction}} = -82 + (-92) - (-75)$$
- $$= -99 \text{ kJ mol}^{-1} \quad (1)$$
- (ii)
- | | | | | | | | | |
|--------|---------------|---|--------------|---------------|-----------------------|---|-------------|-----|
| | CH_4 | + | I_2 | $\rightarrow$ | CH_3I | + | HI | |
| broken | C-H | | I-I | made | C-I | | H-I | |
| | 410 | | 151 | | 240 | | 299 | (1) |
- $$\Delta H^\circ_{\text{reaction}} = -240 + (-299) + 410 + 151$$
- $$= +22 \text{ kJ mol}^{-1} \quad (1)$$
- (iii) activation energy is too great (1) [5]
- (b) (i) initiation (1)
- $$\text{Cl}_2 + \text{uvl} \rightarrow 2\text{Cl} \quad (1)$$
- propagation (1)
- $$\text{CH}_4 + \text{Cl} \rightarrow \text{CH}_3 + \text{HCl}$$
- $$\text{CH}_3 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{Cl} \quad \text{both needed (1)}$$
- termination (1)
- $$\text{CH}_3 + \text{CH}_3 \rightarrow \text{C}_2\text{H}_6 \text{ or}$$
- $$\text{CH}_3 + \text{Cl} \rightarrow \text{CH}_3\text{Cl} \text{ or}$$
- $$\text{Cl} + \text{Cl} \rightarrow \text{Cl}_2 \quad (1)$$
- (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) (ii)) (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]

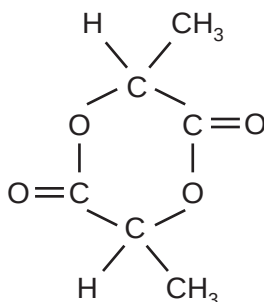
(b) (i) carboxylic acid/carboxyl/–CO₂H
not acid (1)

(ii) H is CH₃CO₂H/ethanoic acid (1)

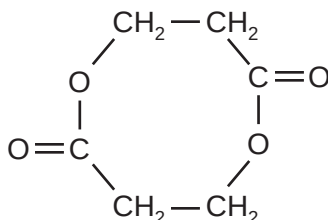
(iii) J is CH₃CH(OH)CO₂H/2-hydroxypropanoic acid
allow HOCH₂CH₂CO₂H/3-hydroxypropanoic acid (1) [3]

(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]

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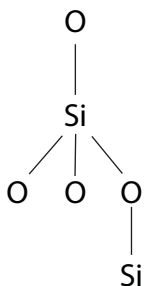
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- 1 (a) CO₂ is simple molecular/simple covalent/has discrete molecules (1)
 CO₂ has induced dipole – induced dipole interactions/ (1)
 van der Waals' forces/weak intermolecular forces (1)
 SiO₂ is giant molecular/giant covalent/macromolecular (1)
 SiO₂ has strong covalent bonds (1)
 [any 3]

- (b) minimum is 4-valent Si-O (1)
 and at least one Si-O-Si (1)
 i.e.



[2]

- (c) (i) for an ideal gas, **any four** from the following (1)
 the molecules behave as rigid spheres (1)
 there are no/negligible intermolecular forces (1)
 between the molecules (1)
 collisions between the molecules are perfectly elastic (1)
 the molecules have no/negligible volume (1)
 the molecules move in random motion (1)
 the molecules move in straight lines (1)
 the kinetic energy of the molecules is (1)
 directly proportional to the temperature (1)
 the pressure exerted by the gas is due to the collisions (1)
 between the gas molecules and the walls of the container (1)
not an ideal gas obeys $pV = nRT$

(max 4)

- (ii) there are intermolecular forces between CO₂ molecules/ (1)
 CO₂ molecules have volume (1) [5]

- (d) graphite has delocalised electrons (1) [1]

- (e) (i) SiO₂ + 2C → SiC + CO₂ **or** (1)
 SiO₂ + 3C → SiC + 2CO (1)

- (ii) diamond **because** SiC is hard (1) [2]

[Total: 13]

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2 (a) (i)

formula of chloride	NaCl	MgCl ₂	AlCl ₃	SiCl ₄	PCl ₃	SCl ₂
oxidation number of element in the chloride	+1	+2	+3	+4	+3	+2

correct oxidation nos. for NaCl to SCl₂ (1)

(ii) Na to Al

loss of outer/valence electrons (1)

to give configuration of Ne/to complete octet (1)

Si to S

gain or sharing of outer electrons (1)

to give configuration of Ar/to complete octet (1) [5]

(b) (i) giant lattice (may be in diagram) (1)
with strong ionic bonding (1)

(ii) ionic (1)

(iii) –1 (1)

(iv) $\begin{array}{c} \cdot\cdot + \\ : \text{Na} : \\ \cdot\cdot \end{array} \quad \begin{array}{c} - \\ \times \cdot \text{H} \\ - \end{array}$

correct numbers of electrons (1)

correct charges (1)

(v)

compound	MgH ₂	AlH ₃	PH ₃	H ₂ S
oxidation number of element in the hydride	+2	+3	–3	–2

correct oxidation nos. for MgH₂ and AlH₃ (1)

correct oxidation nos. for PH₃ and H₂S (1) [8]

(c) (i)

chloride	sodium	magnesium	aluminium
pH	7	6.5–6.9	1–4

(no mark)

(1)

(1)

(ii) NaH + H₂O → NaOH + H₂ (1)

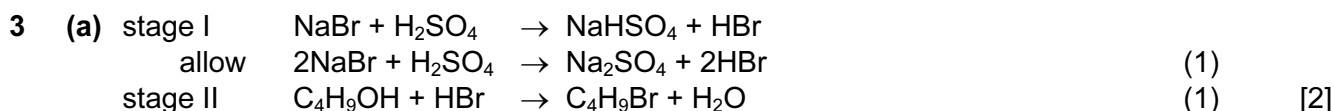
(iii) 10–14 (1) [4]

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(d) (i) covalent (1)



[Total: 19]

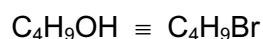


(b) $n(\text{NaBr}) = n(\text{HBr}) = \frac{35}{103} = 0.34$ (1)

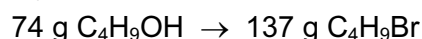
$n(\text{C}_4\text{H}_9\text{OH}) = \frac{20}{74} = 0.27$ (1)

NaBr/HBr is in an excess – no mark just for this answer [2]

(c) method 1, using mass



if yield is 100%,



$15.4 \text{ g C}_4\text{H}_9\text{OH}$ would produce $\frac{137 \times 15.4}{74} = 28.5 \text{ g C}_4\text{H}_9\text{Br}$ (1)

% yield = $\frac{22.5 \times 100}{28.5} = 78.9$ (1)

or methods using moles

method 2

$n(\text{C}_4\text{H}_9\text{OH}) = \frac{15.4}{74} = 0.208$

for 100% yield $n(\text{C}_4\text{H}_9\text{Br})$ would be $0.208 \times 137 = 28.5\text{g}$ (1)

% yield = $\frac{22.5 \times 100}{28.5} = 78.9$ (1)

method 3

$n(\text{C}_4\text{H}_9\text{OH}) = \frac{15.4}{74} = 0.208 \text{ mol}$

for 100% yield $n(\text{C}_4\text{H}_9\text{Br})$ would be 0.208 mol

actual $n(\text{C}_4\text{H}_9\text{Br}) = \frac{22.5}{137} = 0.164 \text{ mol}$ (1)

% yield = $\frac{0.164 \times 100}{0.208} = 78.8$ (1) [2]

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(d) inorganic by-product

Br₂/bromine or sulfur dioxide/SO₂

(1)

conc. H₂SO₄ behaves as an oxidising agent

(1)

organic by-product

but-1-ene/CH₃CH₂CH=CH₂

(1)

allow butane and C₄H₉OC₄H₉

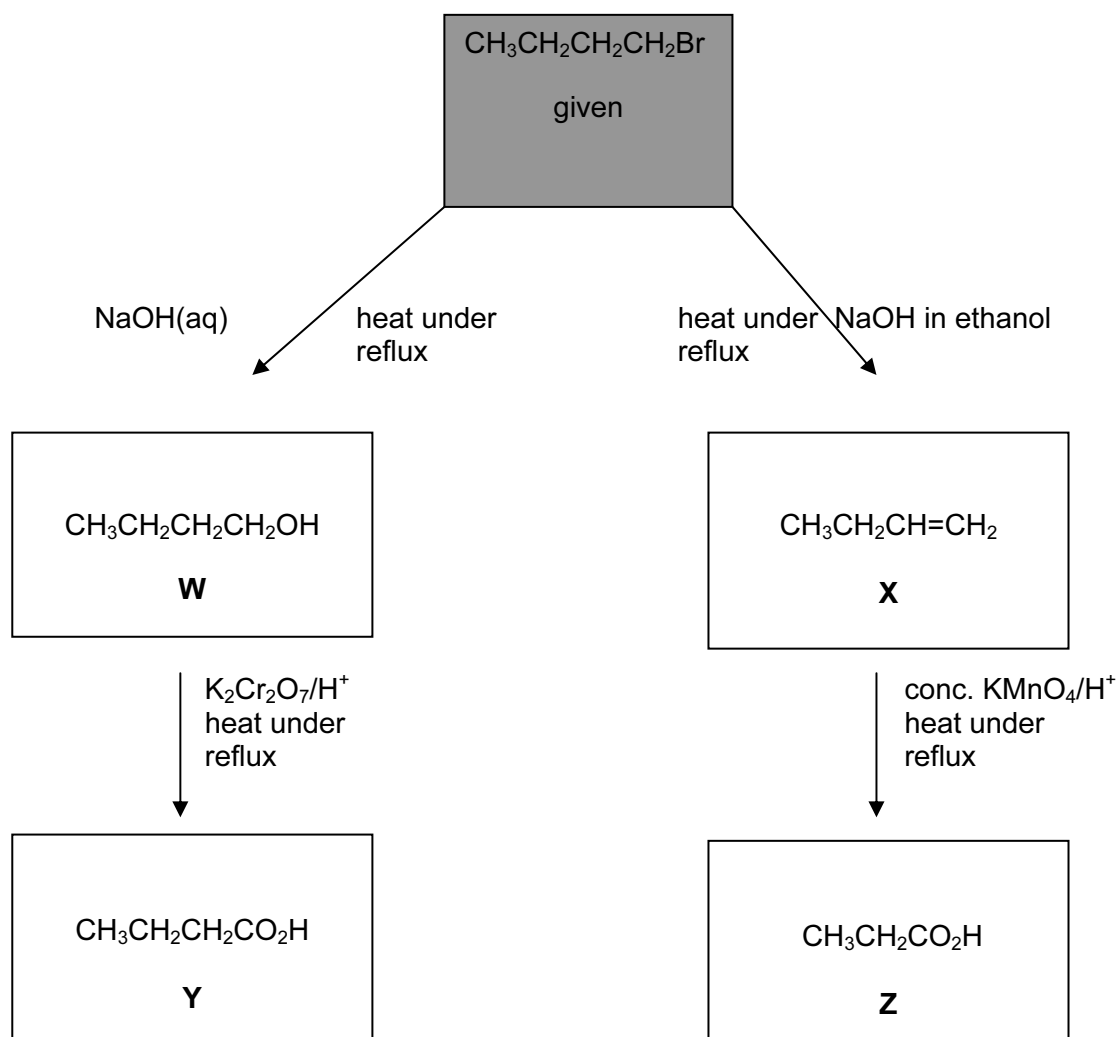
conc. H₂SO₄ behaves as a dehydrating agent

(1)

[4]

[Total: 10]

4 (a)

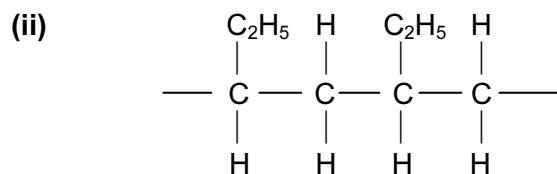


(4 × 1)

[4]

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- (b) (i) **X**
allow ecf on any alkene above (1)



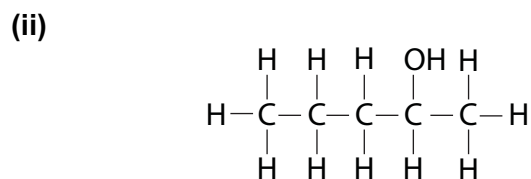
allow ecf on any alkene above (1) [2]

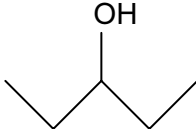
[Total: 6]

- 5 (a) 2,4-dinitrophenylhydrazine **or** aqueous alkaline iodine (1)
↓ ↓
yellow-orange-red ppt. yellow ppt. (1) [2]

- (b) colourless gas evolved **or** Na dissolves (1)
 $\text{C}_4\text{H}_9\text{OH} + \text{Na} \rightarrow \text{C}_4\text{H}_9\text{ONa} + \frac{1}{2}\text{H}_2$ (1) [2]

- (c) (i) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ (1)



- (iii)
- 
- (1) [3]

- (d) (i) pentan-2-ol (1)

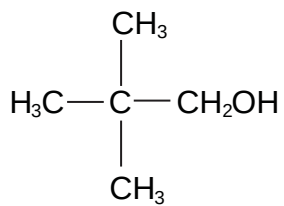
(ii)

$\text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}_3$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}=\text{CH}_2$
product 1	product 2

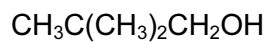
(1 + 1) [3]

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(e) (i)

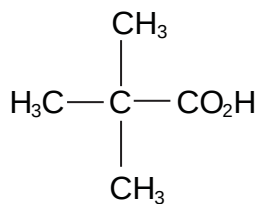


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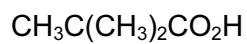


(1)

(ii)



or



allow ecf on (e)(i)

(1) [2]

[Total: 12]