

**MARK SCHEME for the May/June 2010 question paper  
for the guidance of teachers**

**9701 CHEMISTRY**

**9701/21**

Paper 2 (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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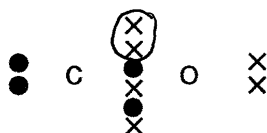


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|--------|--------------------------------|----------|-------|
| Page 2 | Mark Scheme: Teachers' version | Syllabus | Paper |
|        | GCE AS/A LEVEL – May/June 2010 | 9701     | 21    |

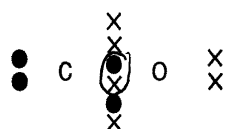
- 1 (a) fewer electrons in  $Cl_2$  than in  $Br_2$  (1)  
smaller van der Waals' forces in  $Cl_2$  **or** stronger van der Waals' forces in  $Br_2$  (1) [2]

- (b) CO has a permanent dipole **or**  $N_2$  does not (1)  
permanent dipole-permanent dipole interactions are stronger than those from induced dipoles (1) [2]

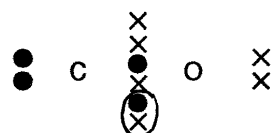
- (c) (i) a co-ordinate bond (1)



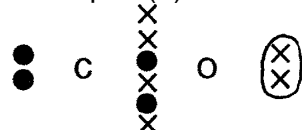
- (ii) a covalent bond (1)



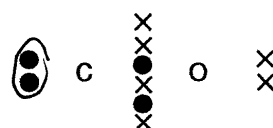
or



- (iii) a lone pair (1)



or

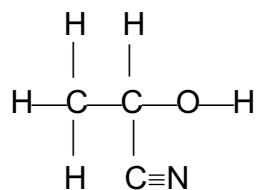


penalise any groups of 3 or 4 electrons that are circled [3]

- (d) CO and HCN both have a dipole **or**  $N_2$  does not have a dipole (1) [1]

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|--------|--------------------------------|----------|-------|
| Page 3 | Mark Scheme: Teachers' version | Syllabus | Paper |
|        | GCE AS/A LEVEL – May/June 2010 | 9701     | 21    |

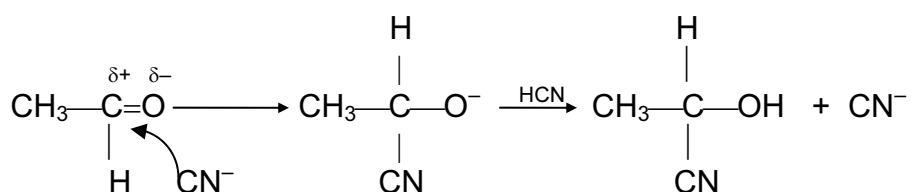
(e) (i)



C≡N must be shown (1)

(ii) nucleophilic addition (1)

(iii)



C=O dipole correctly shown **or** correct curly arrow on C=O (1)

attack on C<sup>δ+</sup> by C of CN<sup>-</sup> (1)

correct intermediate (1)

CN<sup>-</sup> regenerated (1)

[5 max]

**[Total: 13]**

|               |                                       |                 |              |
|---------------|---------------------------------------|-----------------|--------------|
| <b>Page 4</b> | <b>Mark Scheme: Teachers' version</b> | <b>Syllabus</b> | <b>Paper</b> |
|               | <b>GCE AS/A LEVEL – May/June 2010</b> | <b>9701</b>     | <b>21</b>    |

- 2 (a) (i) new graph has **lower** maximum (1)  
maximum is **to the right of** previous maximum (1)
- (ii) **H** is at  $E_a$  (1) [3]
- (b) the minimum amount of energy molecules must have **or** energy required (1)  
in order for the reaction to take place (1) [2]
- (c) (i) iron **or** iron oxide (1)  
100 to 500 atm **and** 400–550°C  
units necessary – allow other correct values and units (1)
- (ii) **C** is placed to the left of **H** (1)
- (iii) more molecules now have energy  $>E_a$  (1) [4]
- (d) **reaction 1**  
has greater  $E_a$  (1)  
because energy is needed to break covalent bonds (1)  
**reaction 2**  
has lower  $E_a$   
**or** actual reaction is  $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$   
**or** reaction involves ions (1)  
opposite charges attract (1) [4]

**[Total: max 12]**

|               |                                       |                 |              |
|---------------|---------------------------------------|-----------------|--------------|
| <b>Page 5</b> | <b>Mark Scheme: Teachers' version</b> | <b>Syllabus</b> | <b>Paper</b> |
|               | <b>GCE AS/A LEVEL – May/June 2010</b> | <b>9701</b>     | <b>21</b>    |

**3 (a)** Accept only symbols.

- (i) S or S<sub>8</sub> (1)
- (ii) K or K<sup>+</sup> (1)
- (iii) Na – allow K or Li (1)
- (iv) Cl or Br or F (1)
- (v) Mg or Ca or Li  
allow Ni, Cu, or Zn (1)

[5]

**(b)** Accept only formulae.

- (i) F<sub>2</sub>O (1)
- (ii) SO<sub>2</sub> and SO<sub>3</sub>  
or P<sub>2</sub>O<sub>3</sub>/P<sub>4</sub>O<sub>6</sub> and P<sub>2</sub>O<sub>5</sub>/P<sub>4</sub>O<sub>10</sub>  
or any two from N<sub>2</sub>O<sub>3</sub>, NO<sub>2</sub>/N<sub>2</sub>O<sub>4</sub>, N<sub>2</sub>O<sub>5</sub>  
or any two from Cl<sub>2</sub>O, ClO<sub>2</sub>, ClO<sub>3</sub>, Cl<sub>2</sub>O<sub>7</sub> (1+1)

[3]

**(c) (i)** NaF, MgF<sub>2</sub>, AlF<sub>3</sub> – any two (1)

(ii) octahedral (1)

(iii) I atom is larger than Cl atom (1)

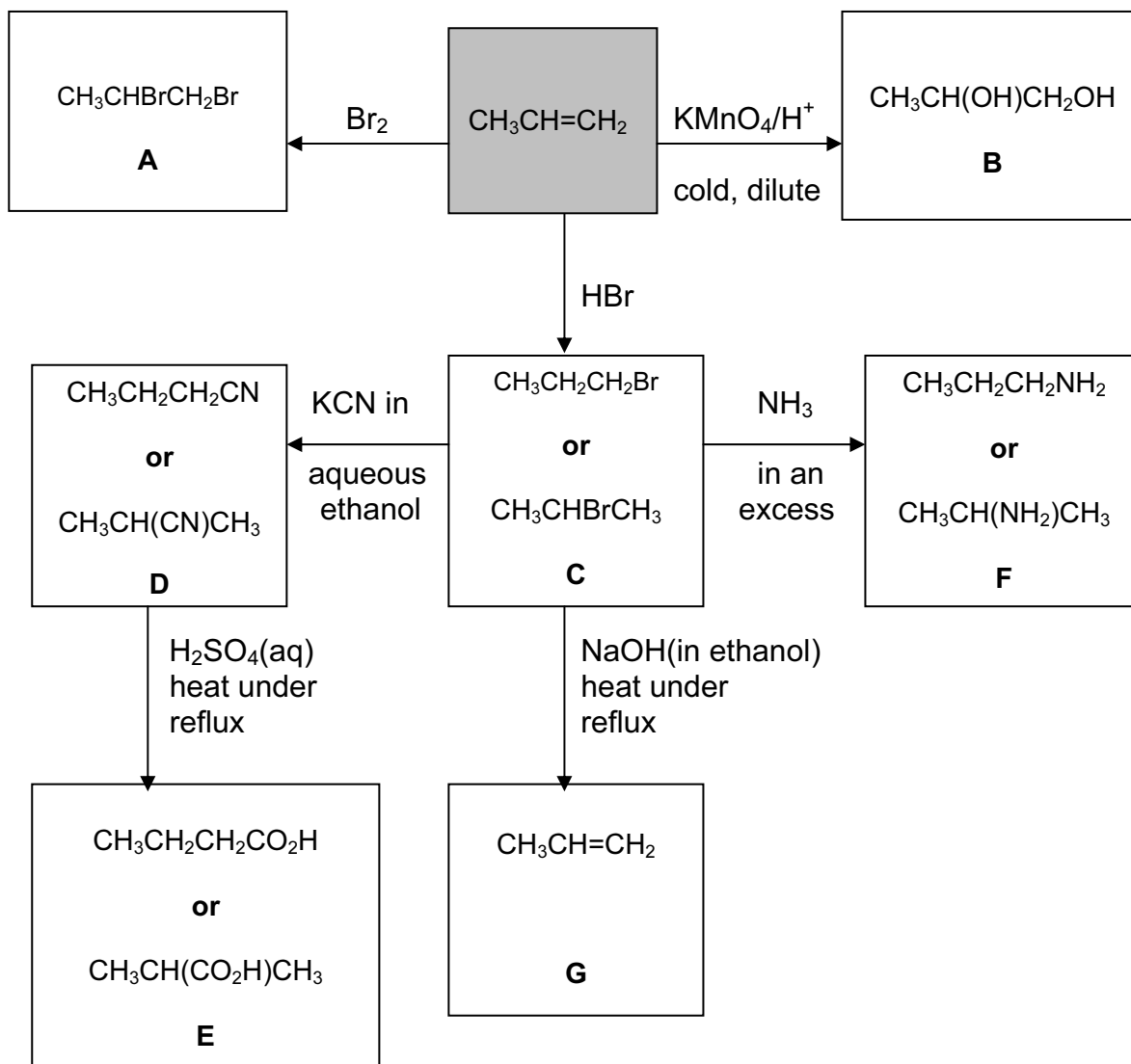
(iv) cannot pack 7 F atoms around Cl atom  
or can pack 7 F atoms around I atom (1)

[4]

**[Total: 12]**

|        |                                |          |       |
|--------|--------------------------------|----------|-------|
| Page 6 | Mark Scheme: Teachers' version | Syllabus | Paper |
|        | GCE AS/A LEVEL – May/June 2010 | 9701     | 21    |

4 (a)



give 1 for each correct structure ( $7 \times 1$ )

[7]

(b) (i) ester (1)

(ii) heat under reflux (1)  
trace of conc.  $\text{H}_2\text{SO}_4$  or presence of  $\text{HCl}(\text{g})$  (1)

[3]

[Total: 10]

|        |                                |          |       |
|--------|--------------------------------|----------|-------|
| Page 7 | Mark Scheme: Teachers' version | Syllabus | Paper |
|        | GCE AS/A LEVEL – May/June 2010 | 9701     | 21    |

- 5 (a) (i) same molecular formula  
but different structural formula/structure (1)
- (ii) asymmetric C atom/chiral centre present (1)  
>C=C< bond present (1) [3]
- (b)  $\text{NaO}_2\text{CCH(OH)CH(OH)CO}_2\text{Na}$  (1) [1]
- (c) no **because** there is no chiral carbon atom present (1) [1]
- (d) (i)  $\text{C} : \text{H} : \text{O} = \frac{35.8}{12} : \frac{4.5}{1} : \frac{59.7}{16}$  this mark is for correct use of  $A_r$  values (1)  
 $\text{C} : \text{H} : \text{O} = 2.98 : 4.5 : 3.73$   
 $\text{C} : \text{H} : \text{O} = 1 : 1.5 : 1.25$  this mark is for evidence of correct calculation (1)  
gives empirical formula of **W** is  $\text{C}_4\text{H}_6\text{O}_5$
- (ii)  $\text{C}_4\text{H}_6\text{O}_5 = 12 \times 4 + 1 \times 6 + 16 \times 5 = 134$   
molecular formula of **W** is  $\text{C}_4\text{H}_6\text{O}_5$  (1) [3]

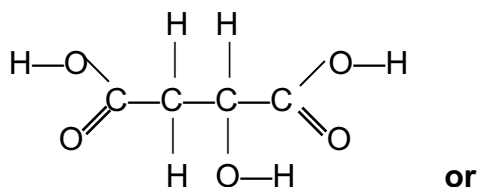
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|--------|--------------------------------|----------|-------|
| Page 8 | Mark Scheme: Teachers' version | Syllabus | Paper |
|        | GCE AS/A LEVEL – May/June 2010 | 9701     | 21    |

(e) (i)  $n(\text{OH}^-) = \frac{29.4 \times 100}{1000} = 0.0294$  (1)  
 $n(\text{W}) = \frac{1.97}{134} = 0.0147$  (1)  
 no. of  $-\text{CO}_2\text{H}$  groups present  
 in one molecule of **W** =  $\frac{0.0294}{0.0147} = 2$  (1)

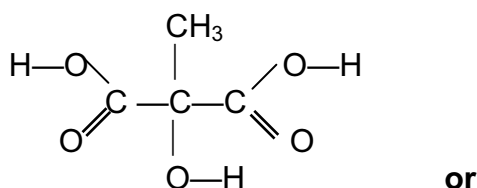
or  $n(\text{OH}^-) = \frac{29.4 \times 1.00}{1000} = 0.0294$  (1)  
 $1.97 \text{ g W} \equiv 0.0294 \text{ mol NaOH}$   
 $134 \text{ g W} \equiv \frac{0.0294 \times 134}{1.97} = 1.999 \approx 2 \text{ mol NaOH}$  (1)  
 no. of  $-\text{CO}_2\text{H}$  groups present in 1 molecule of **W** = 2 (1)

[3]

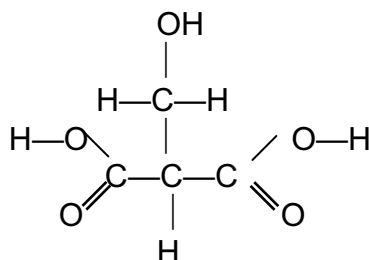
(ii)



or



or



one correct structure (1)  
 correctly displayed (1)  
 allow any **correct** ether

[2]

[Total: 13]

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Paper 2 (AS Structured Questions), maximum raw mark 60

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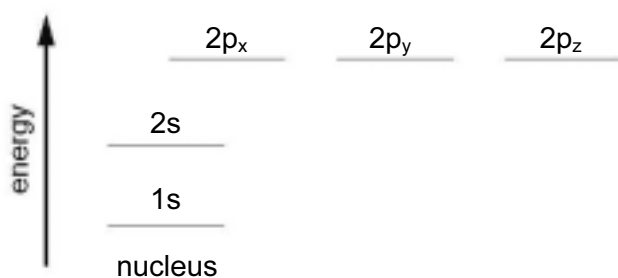
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|        |                                |          |       |
|--------|--------------------------------|----------|-------|
| Page 2 | Mark Scheme: Teachers' version | Syllabus | Paper |
|        | GCE AS/A LEVEL – May/June 2010 | 9701     | 22    |

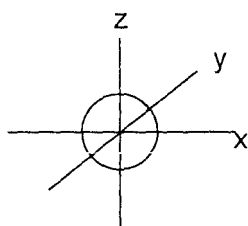
1 (a) (i)



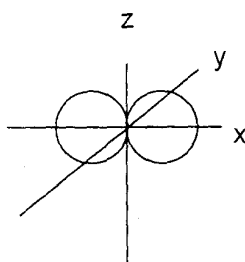
correct 1s and 2s (1)

correct  $2p_x$ ,  $2p_y$  and  $2p_z$  (1)

(ii)



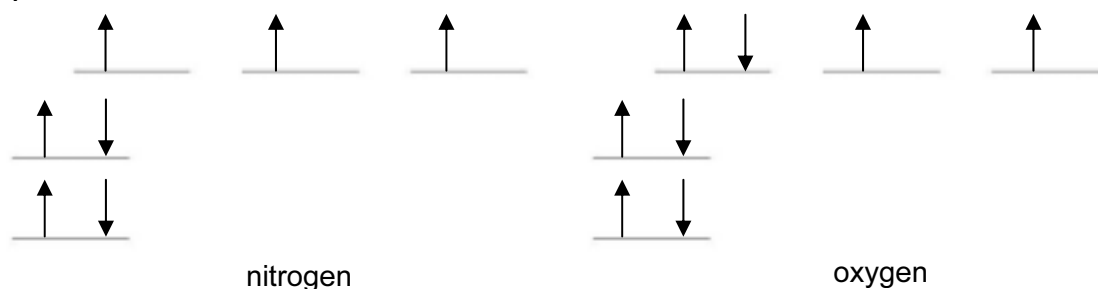
spherical s orbital (1)



double lobed p orbital along one axis (1)

both orbitals correctly labelled (1)

(iii)



both correct (1)

[6]

(b) (i) N  $1400 \text{ kJ mol}^{-1}$  O  $1310 \text{ kJ mol}^{-1}$  **both** (1)

(ii) N is all singly filled 2p orbitals **or** O has one filled/paired 2p orbital (1)  
these paired 2p electrons in the O atom repel one another (1)

[3]

**[Total: 9]**

|               |                                       |                 |              |
|---------------|---------------------------------------|-----------------|--------------|
| <b>Page 3</b> | <b>Mark Scheme: Teachers' version</b> | <b>Syllabus</b> | <b>Paper</b> |
|               | <b>GCE AS/A LEVEL – May/June 2010</b> | <b>9701</b>     | <b>22</b>    |

2 (a)

| element | particle                | formula                                 |
|---------|-------------------------|-----------------------------------------|
| copper  | cation                  | $\text{Cu}^{2+}$<br>allow $\text{Cu}^+$ |
| argon   | atom <b>or</b> molecule | Ar                                      |

one mark for each correct row **or** column ( $2 \times 1$ )

[2]

(b) **Cu** cations held in 'sea' of delocalised electrons (1)  
by strong metallic bonds (1)

**Ar** van der Waals' forces between molecules (1)  
which are weak (1)

[4]

(c) (i) oxidising agent **or** electron acceptor (1)

Ar has very high first I.E

**or**  $E_a$  for reaction is very high

**or** Ar has full valency shell/complete octet (1)

[2]

(d) from Ne to Xe more electrons in atom (1)

hence more induced dipoles/van der Waals' forces (1)

[2]

**[Total: 10]**

|               |                                       |                 |              |
|---------------|---------------------------------------|-----------------|--------------|
| <b>Page 4</b> | <b>Mark Scheme: Teachers' version</b> | <b>Syllabus</b> | <b>Paper</b> |
|               | <b>GCE AS/A LEVEL – May/June 2010</b> | <b>9701</b>     | <b>22</b>    |

**3 (a)**

|           |                   |       |                                |                  |                               |                 |
|-----------|-------------------|-------|--------------------------------|------------------|-------------------------------|-----------------|
| oxide     | Na <sub>2</sub> O | MgO   | Al <sub>2</sub> O <sub>3</sub> | SiO <sub>2</sub> | P <sub>4</sub> O <sub>6</sub> | SO <sub>2</sub> |
| bonding   | ionic             | ionic | ionic/covalent                 | covalent         | covalent                      | covalent        |
| structure | giant             | giant | giant                          | giant            | simple                        | simple          |

(i) fully correct 'bonding' row (1)

(ii) fully correct 'structure' row (1) [2]

(b) Al<sub>2</sub>O<sub>3</sub> or SiO<sub>2</sub> (1) [1]

(c) (i) Na<sub>2</sub>O      Na<sub>2</sub>O + H<sub>2</sub>O → 2NaOH (1)  
pH 10–14 (1)

SO<sub>2</sub>      SO<sub>2</sub> + H<sub>2</sub>O → H<sub>2</sub>SO<sub>3</sub> (1)  
pH 2–5 (1)

(ii) NaOH + H<sub>2</sub>SO<sub>3</sub> → NaHSO<sub>3</sub> + H<sub>2</sub>O  
or 2NaOH + H<sub>2</sub>SO<sub>3</sub> → Na<sub>2</sub>SO<sub>3</sub> + 2H<sub>2</sub>O (1) [5]

(d) MgO(l) conducts (1)  
MgO(l) contains free/mobile ions (1)  
SiO<sub>2</sub>(l) does not conduct (1)  
SiO<sub>2</sub>(l) has no free ions (1) [4]

**[Total: 12]**

|        |                                |          |       |
|--------|--------------------------------|----------|-------|
| Page 5 | Mark Scheme: Teachers' version | Syllabus | Paper |
|        | GCE AS/A LEVEL – May/June 2010 | 9701     | 22    |

4 (a)  $C : H : O = \frac{48.7}{12} : \frac{8.1}{1} : \frac{43.2}{16}$  (1)  
 $= 4.06 : 8.1 : 2.70$   
 $= 1.5 : 3 : 1$   
 $= 3 : 6 : 2$

empirical formula is  $C_3H_6O_2$  (1)

[2]

(b) (i)  $M_r = \frac{mRT}{pV} = \frac{0.13 \times 8.31 \times 400}{1.00 \times 10^5 \times 58.0 \times 10^{-6}}$  (1)

$= 74.5$  (1)

(ii)  $C_3H_6O_2 = 36 + 6 + 32 = 74$  (1)

$n(C_3H_6O_2) = 74.5$

hence molecular formula of **E** is  $C_3H_6O_2$  (1)

[4]

(c) structures of **F** are

|                   |                     |                    |                    |
|-------------------|---------------------|--------------------|--------------------|
| $HCO_2CH(CH_3)_2$ | $HCO_2CH_2CH_2CH_3$ | $CH_3CO_2CH_2CH_3$ | $CH_3CH_2CO_2CH_3$ |
| <b>S</b>          | <b>T</b>            | <b>U</b>           | <b>V</b>           |

each correct structure is worth one mark ( $3 \times 1$ )

[3]

(d) (i)  $H_2SO_4/HCl$ /mineral acid **or**  $NaOH/KOH$  (1)

(ii) carboxylic acid **not** 'acid' (1)

[2]

(e) (i) aldehyde (1)

(ii) must be a primary alcohol (1)

(iii)  $CH_3OH$  **or**  $CH_3CH_2OH$  **or**  $CH_3CH_2CH_2OH$  (1)

[3]

(f) (i) **S** (1)

(ii) only **S** is **not** the ester of a primary alcohol  
**or** only **S** is the ester of a secondary alcohol (1)

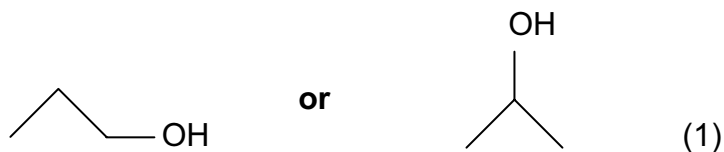
[2]

[Total: 16]

|               |                                       |                 |              |
|---------------|---------------------------------------|-----------------|--------------|
| <b>Page 6</b> | <b>Mark Scheme: Teachers' version</b> | <b>Syllabus</b> | <b>Paper</b> |
|               | <b>GCE AS/A LEVEL – May/June 2010</b> | <b>9701</b>     | <b>22</b>    |

5 (a) (i) propan-1-ol **or** propan-2-ol (1)

(ii)



(iii) dehydration **or** elimination (1) [3]

(b) (i) carbon (1)  
by decomposition/cracking of the alcohol (1)

(ii) to avoid 'sucking back' of water into the hot tube (1)

(iii) SiO<sub>2</sub> (1)

(iv) conc. H<sub>2</sub>SO<sub>4</sub> **or** P<sub>4</sub>O<sub>10</sub> **or** Al<sub>2</sub>O<sub>3</sub> **or** H<sub>3</sub>PO<sub>4</sub> (1) [5]

(c) (i) CH<sub>3</sub>CHBrCH<sub>2</sub>Br (1)

(ii) CH<sub>3</sub>CH(OH)CH<sub>2</sub>OH (1)

(iii) CH<sub>3</sub>CO<sub>2</sub>H (1) [3]

(d) (i) (very) high pressure **or** Ziegler-Natta catalyst (1)

(ii) does not biodegrade **or** gives harmful combustion products (1) [2]

**[Total: 13]**

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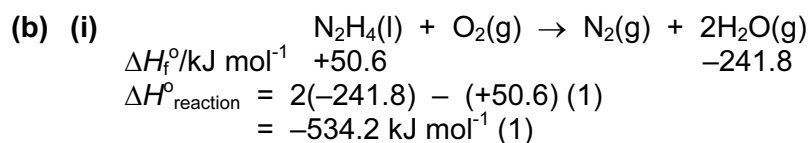
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| Page 2 | Mark Scheme: Teachers' version | Syllabus | Paper |
|        | GCE AS/A LEVEL – May/June 2010 | 9701     | 23    |

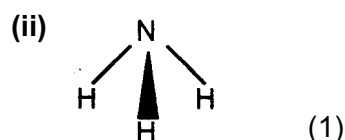
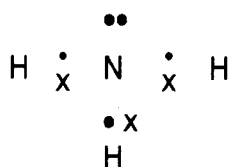
- 1 (a) enthalpy change when 1 mol of a compound is formed (1)  
 from its elements (1)  
 in their standard states under standard conditions (1) [3]



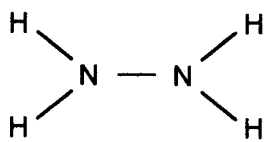
(ii)  $E_a$  is too high (1)

(iii) products are  $\text{H}_2\text{O}$  and  $\text{N}_2$  which are harmless/non toxic  
 or are already present in the atmosphere (1) [4]

(c) (i) 'dot-and-cross' diagram (1)



(iii) minimum is



allow bond angle around N atom between  $109^\circ$  and  $104^\circ$  (1) [4]

(d)  $-2$  (1) [1]

[Total: 12]

|               |                                       |                 |              |
|---------------|---------------------------------------|-----------------|--------------|
| <b>Page 3</b> | <b>Mark Scheme: Teachers' version</b> | <b>Syllabus</b> | <b>Paper</b> |
|               | <b>GCE AS/A LEVEL – May/June 2010</b> | <b>9701</b>     | <b>23</b>    |

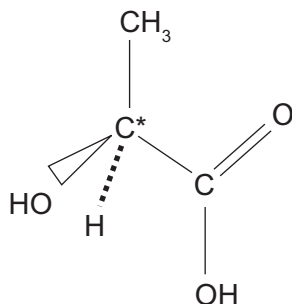
- 2 (a) the energy required to remove one electron from each atom (1)  
in one mole of gaseous atoms (1)  
**or**  
the enthalpy change in  $\text{kJ mol}^{-1}$  for (1)  
 $\text{M(g)} \rightarrow \text{M}^+(\text{g}) + \text{e}^-$  (1) [2]
- (b) (i) first ionisation energy decreases down Group 1 (1)  
outermost electron is further from nucleus  
or has greater shielding (1)
- (ii) outermost electron experiences less attraction  
**or** formation of  $\text{M}^+$  cation becomes easier down Group 1 (1) [3]
- (c) (i)  $n(\text{Li}) = \frac{0.83}{6.9} = 0.12$  (1)
- (ii)  $2 \text{ mol Li} \rightarrow 1 \text{ mol H}_2$   
 $0.12 \text{ mol Li} \rightarrow \frac{1 \times 0.12}{2} = 0.06 \text{ mol H}_2$  (1)  
volume of  $\text{H}_2 = 0.06 \times 24.0 = 1.44 \text{ dm}^3$  (1)
- (iii)  $2 \text{ mol Li} \rightarrow 2 \text{ mol LiOH}$   
 $0.12 \text{ mol Li} \rightarrow 0.12 \text{ mol LiOH in } 0.50 \text{ dm}^3$  (1)  
 $[\text{LiOH}] = \frac{0.12 \times 1}{0.50} = 0.24 \text{ mol dm}^{-3}$  (1) [5]
- (d) sodium burns with a yellow flame  
**or** white solid formed  
**or** colour of chlorine disappears (1)
- $2\text{Na} + \text{Cl}_2 \rightarrow 2\text{NaCl}$  (1) [2]

**[Total: 12]**

|               |                                       |                 |              |
|---------------|---------------------------------------|-----------------|--------------|
| <b>Page 4</b> | <b>Mark Scheme: Teachers' version</b> | <b>Syllabus</b> | <b>Paper</b> |
|               | <b>GCE AS/A LEVEL – May/June 2010</b> | <b>9701</b>     | <b>23</b>    |

- 3 (a) (i)** Ca (1)
- (ii) S **or** C [allow H (H<sub>2</sub>O<sub>2</sub>) or N (NO, NO<sub>2</sub>)] (1)
- (iii) He (1)
- (iv) Al (1)
- (v) Si **or** Ge (1)
- (vi) Al (1) [6]
- (b)** any **two** from N **or** O **or** F (1) [1]
- (c) (i)** Al<sub>2</sub>O<sub>3</sub> **or** SiO<sub>2</sub> (1)
- (ii) SO<sub>2</sub> **or** P<sub>2</sub>O<sub>3</sub>/P<sub>4</sub>O<sub>6</sub> (1)  
and and  
SO<sub>3</sub> **or** P<sub>2</sub>O<sub>5</sub>/P<sub>4</sub>O<sub>10</sub> (1)
- (iii) Na<sub>2</sub>O (1)
- (iv) Al<sub>2</sub>O<sub>3</sub> (1) [5]
- [Total: 12]**
- 4 (a) reaction 1** free radical substitution (1)
- reaction 2** elimination (1) [2]
- (b) (i)** in reaction 4 CH<sub>3</sub>C(OH)(CN)CH<sub>3</sub> (1)
- (ii) in reaction 3 I<sup>-</sup> (1)
- (iii) in reaction 3 CH<sub>3</sub>I  
**or** in reaction 4 CH<sub>3</sub>COCH<sub>3</sub> (1) [3]
- (c)** a species which has a lone pair of electrons  
**or** which reacts with an electron deficient (δ<sup>+</sup>) centre in a molecule (1) [1]
- (d)** in reaction 3 OH<sup>-</sup> (1)  
in reaction 4 CN<sup>-</sup> (1) [2]
- (e)** π bonding is electron rich (1) [1]
- [Total: 9]**

5 (a)



[3]

(b)

|        | reagent(s)                                                                                | condition(s)               |
|--------|-------------------------------------------------------------------------------------------|----------------------------|
| step 1 | $\text{Cr}_2\text{O}_7^{2-} / \text{H}^+$<br>(1)                                          | distil off aldehyde<br>(1) |
| step 2 | HCN in presence of $\text{CN}^-$<br>or<br>$\text{KCN} + \text{dil H}_2\text{SO}_4$<br>(1) | room temperature<br>(1)    |
| step 3 | aqueous mineral acid/ $\text{H}_2\text{SO}_4/\text{HCl}/$<br>not $\text{HNO}_3$<br>(1)    | heat under reflux<br>(1)   |

in **each** case, the reagent must be correct before the condition mark is awarded

[6]

(c) (i) a protein (1)

(ii) 2,4-dinitrophenylhydrazine/Brady's reagent (1)  
yellow-orange-red ppt. (1)

(iii) acidified  $\text{K}_2\text{Cr}_2\text{O}_7$  or Lucas test or  $\text{CH}_3\text{CO}_2\text{H}/\text{H}^+$  (1)  
colour changes or cloudiness or fruity smell  
from orange to green (1)

(iv)  $\text{LiAlH}_4/\text{NaBH}_4$   
or  $\text{H}_2/\text{Ni}$  etc. (1)

[6]

[Total: 15]