CAMBRIDGE INTERNATIONAL EXAMINATIONS

Pre-U Certificate

MARK SCHEME for the May/June 2014 series

9791 CHEMISTRY

9791/02 Paper 2 (Part A Written), maximum raw mark 100

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 should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2014 series for most IGCSE, Pre-U, GCE Advanced Level and Advanced Subsidiary Level components and some Ordinary Level components.

1 **(a)** **(i)** $\Delta_r H^\ominus$ (298 K) = (−110.5 – (−393.5 – 285.8)) kJ mol^{-1} = +568.8 kJ mol^{-1}
1 mark for the working (1)
1 mark for correct answer with sign (1) [2]

(ii) Catalyst OR (provides alternative mechanism) lowering activation energy / E_a (1) [1]

(b) **(i)** The enthalpy / energy change when one mole (1) of substance is combusted completely (or in excess oxygen) (1)
Reference to standard states or standard conditions or 1 bar pressure (1)
Ignore references to temperature.
Energy released when…does not score the first mark. [3]

(ii) $\Delta_c H^\ominus$ (CH_3OH, 298 K) = (128.6 – $\Delta_f H^\ominus$ (CO) + $\Delta_f H^\ominus$ (CO_2) + (2 × $\Delta_f H^\ominus$ (H_2O))) kJ mol^{-1}
= (128.6 + 110.5 − 393.5 – (2 × 285.8)) kJ mol^{-1} = −726.0 kJ mol^{-1}
1 mark for the working (1)
1 mark for correct answer with sign (1)
Alternative method using answer to **(a) (i)**:
$\Delta_c H^\ominus$ (CH_3OH, 298 K) = (128.6 – 568.8 – 285.8) kJ mol^{-1} = −726.0 kJ mol^{-1} [2]

(iii) (Compared to gaseous fuels) it is easier to transport / store liquid fuels OR greater energy density (in a liquid fuel) (1) [1]

(c) **(i)** $CaCO_3 \rightarrow CaO + CO_2$ (1) [1]

(ii) Less energy required because
Smaller radius or greater charge density on Mg^{2+} ion (1)
Compared to the Ca^{2+} ion, the Mg^{2+} ion is more polarising (1)
If 'more energy' is stated, both these arguments required for 1 mark only.
No credit for self-consistent arguments leading to wrong conclusion. [2]

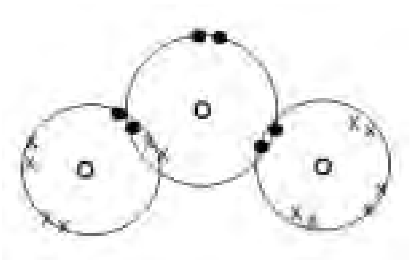
(iii) The CaO from decomposing the limestone can absorb the same amount of CO_2 from the atmosphere as was given off by the combustion of the methanol (1)
$CaCO_3$ / limestone must be mentioned. [1]

[Total: 13]

2 **(a)** Different forms of an <u>element</u> with a different structure / arrangement of atoms (1) [1]

(b) **(i)** Both shared electrons originating from the SAME atom in the bond (1) [1]

(ii)



1 double bond and 1 dative bond from central oxygen atom (1)
8 electrons in the outer shell of each oxygen atom (1) [2]

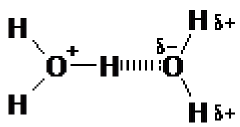
(c) **(i)** The energy (required) to <u>break</u> (1)
a <u>mole of bonds</u> (1)
in the <u>gas</u> phase (1) [3]

(ii) Energy change = $((2 \times 144) – 498)\,\text{kJ mol}^{-1} = -210\,\text{kJ mol}^{-1}$
1 mark for multiplying O–O bond energy by 2 (1)
1 mark for correct answer with correct sign (1) [2]

(d) **(i)** (Trigonal) pyramidal (1)
3 bonding pairs and 1 lone pair (1) [2]

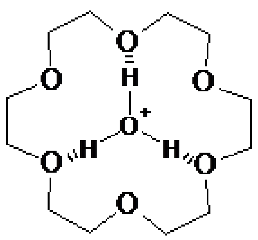
(ii) Ammonia / NH_3 (1) [1]

(e) **(i)** Hydrogen of hydronium cation connected with a <u>labelled</u> hydrogen-bond to the oxygen of a water molecule (1)
180° angle <u>indicated</u> around the H-bonded hydrogen (1)
Lone pair indicated on the oxygen atom in the hydrogen-bond (1)
Both ends of a dipole shown on the water molecule (1)



[4]

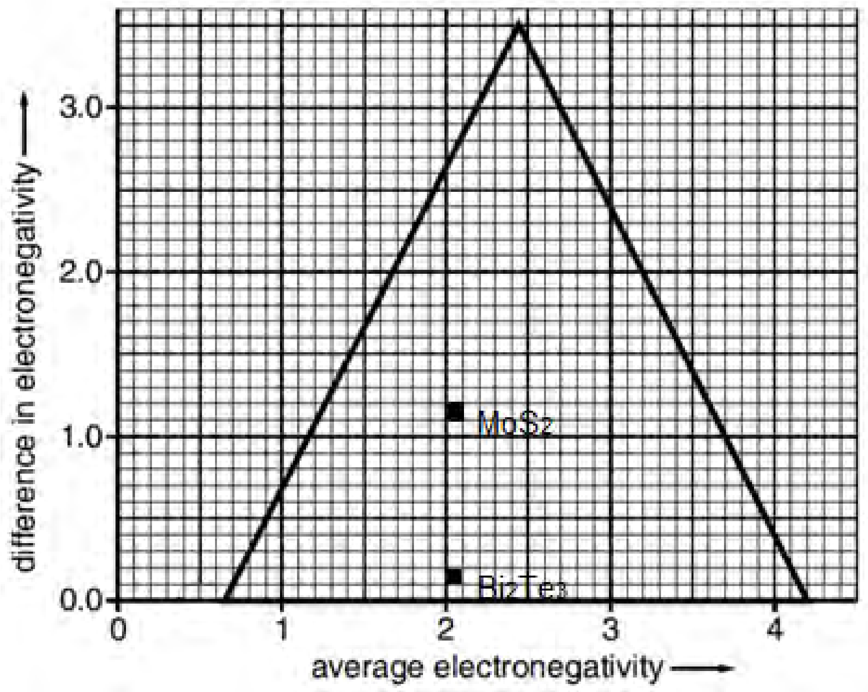
(ii) Hydronium cation inside crown ether with its three hydrogen atoms pointing towards ether oxygens (1)



[1]

[Total: 17]

3 **(a)** **(i)** Points in the correct small squares, correctly labelled (1)

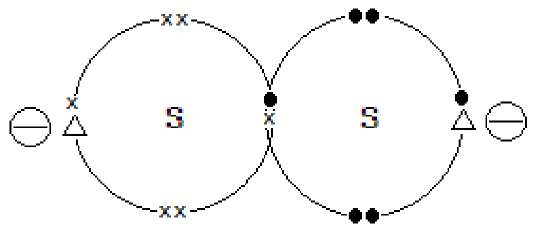


[1]

(ii) **intermediate covalent - metallic** indicated (1) [1]

(iii) **more ionic than Bi_2Te_3** indicated (1) [1]

(b) **(i)**



S−S single bond (1)
Full outer-shells on each sulfur (1)
Charges shown (1) [3]

(ii) (+)4 (1) [1]

(c) **(i)** Simplest whole-number ratio / formula of (atoms of) elements in a compound (1) [1]

(ii) Amount of Na in 100 g = 26.4 g / 23 g mol^{-1} = 1.1478 mol
Amount of S in 100 g = 73.6 g / 32.1 g mol^{-1} = 2.2928 mol
Ratio of Na : S = 1 : 2.3 / 1.1478 = 1.9975 (1)
Simplest whole-number ratio is 1 : 2 (1) [2]

(iii) 4 (1) [1]

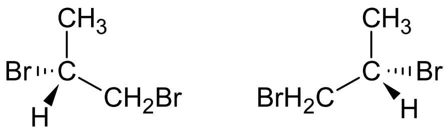
(iv) H−S−S−S−S−H (1) [1]

[Total: 12]

4 (a) (i) $C_3H_8 + 2Br_2 \rightarrow C_3H_6Br_2 + 2HBr$ (1) [1]

(ii) (Radical) substitution (1)
No credit if there is reference to nucleophiles or electrophiles. [1]

(iii)

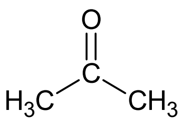


Correct 3D representation of bonding on both molecules i.e. hashes and wedges (1)
Correct enantiomers – mark not awarded if additional enantiomers are given (1) [2]

(iv) 1,2-dibromopropane: 3 (1)
2,2-dibromopropane: 2 (1) [2]

(b) Reagent: sodium hydroxide (1)
Solvent: water (1) [2]

(c)



(1) [1]

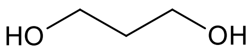
(d) (i) Aldehyde (1) [1]

(ii) FGL 2 to 3 (1) [1]

(iii) Propanedioic acid or 3-oxypropanoic acid (1)
Allow propanoic acid or carboxylic acid or dicarboxylic acid or a reasonable attempt at naming the molecules above. [1]

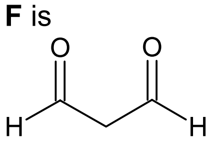
(iv) Amount of 1,3-dibromopropane = $9.0\,g / 201.8\,g\,mol^{-1} = 0.0446\,mol$ (1)
Mass of propanedial = $0.67 \times 0.0446\,mol \times 72\,g\,mol^{-1} = 2.15\,g$ (1) [2]

(v) **E** is



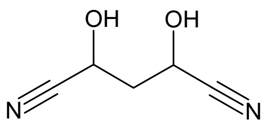
(1)

F is



(1) [2]

(vi) **G** is



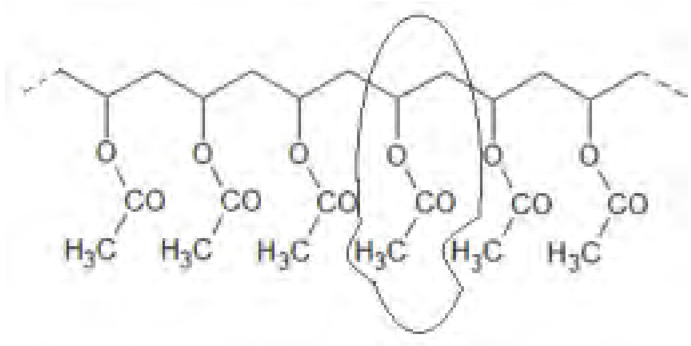
(1) [1]

(e) (i) **H** is $H_2C{=}C{=}CH_2$ (1) [1]

(ii) **I** is $H_3C{-}C{\equiv}C{-}H$ (1) [1]

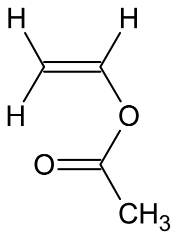
[Total: 19]

5 (a) (i)



(1) [1]

(ii)

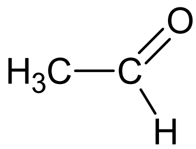


(1) [1]

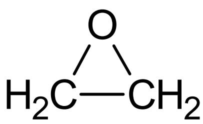
(iii) Ethanoic acid or CH_3COOH or CH_3CO_2H or Na salt (but not allowing O−Na bond) (1) [1]

(iv) (Lots of) hydrogen bonds formed (between the polymer and) with water molecules (1) [1]

(v) Structures of **S** and **T** (either way around)



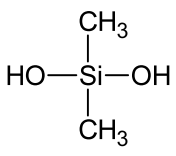
(1)



(1) [2]

(vi) FGL 1 or alcohol level (1)
Epoxyethane identified as monomer as only its carbons are in FGL 1 (1) [2]

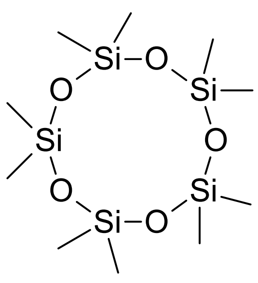
(b) (i) **V** is



(1)

W is HCl (1) [2]

(ii)



(1) [1]

[Total: 11]

6 **(a)** **(i)** Triple bond between C and N and a negative charge on the carbon (1)
One lone pair on each atom (1)

[2]

(ii) Precipitation: $Ag^+(aq) + CN^-(aq) \rightarrow AgCN(s)$ (1)

ALLOW: $2Ag^+(aq) + 2CN^-(aq) \rightarrow Ag[Ag(CN)_2](s)$
OR $Ag^+(aq) + Ag(CN)_2^-(aq) \rightarrow Ag[Ag(CN)_2](s)$

Dissolving: $AgCN(s) + CN^-(aq) \rightarrow Ag(CN)_2^-(aq)$ (1)

ALLOW: $Ag[Ag(CN)_2](s) + 2CN^-(aq) \rightarrow 2Ag(CN)_2^-(aq)$ [2]

(iii) (Initial) white precipitate (1)

Dissolution of precipitate (into colourless solution after shaking) (1) [2]

(b) **(i)** Alkali precipitates the silver ions (1) [1]

(ii) Acidification of cyanides produce hydrogen cyanide (1)
which is a very toxic gas (1) [2]

(c) **(i)** 1 **:** 2 (1) [1]

(ii) Yellow (precipitate) (1) [1]

(iii) AgI is insoluble in ammonia (1) [1]

(d) **(i)** Amount of cyanide ≈ 0.01 mol (1)

Concentration of solution of ≈ 0.1 mol dm^{-3} is convenient (1)

Transfer solid with washings to a beaker OR weighing by difference (1)

Dissolve in a small volume of deionised/distilled water in the beaker (1)

Stir (with glass rod or magnetic stirrer) (1)

Transfer to 100 cm^3 volumetric flask with washings (1)

Make up to the mark <u>with deionised/distilled water</u> (1)

Invert several times or mix thoroughly (only if already filled up to the mark) (1)

Transfer with 10 cm^3 pipette into conical flask (1)

Silver nitrate solution in burette (1)

Add ammonia <u>and</u> sodium iodide (any quantity, apparatus need not be specified) (1)

Add silver nitrate (from burette) with swirling (1)

Add silver nitrate dropwise near the end-point (1)

White tile underneath (conical flask) (1)

Add silver nitrate solution until precipitate appears OR until yellow colour appears (1)

Repeat until consistent titres are obtained or two titres are within 0.1 cm^3 (1)

<u>Maximum for **(d) (i):** 12 marks</u> [12]

(ii) amount of cyanide = 0.269 g / 26 g mol^{-1} = 0.0103 mol (1)

amount of cyanide in titration = 1 / 10 of total = 0.00103 mol (1)

amount of Ag^+ in titration = 0.5 × amount of cyanide = 0.000517 mol (1)

vol Ag^+ in titration = 0.000517 mol / 0.0500 mol dm^{-3} = 10.3 cm^3 (1)

Accept 10.3 cm^3 or 10.35 cm^3.

Final value for titre must be to at least 1 decimal place.

Give credit for variations that follow the method given in **(d) (i).** [4]

[Total: 28]