Cambridge International Examinations
Cambridge Pre-U Certificate

CHEMISTRY **9791/02**

Paper 2 Part A Written **May/June 2016**

MARK SCHEME

Maximum Mark: 100

Published

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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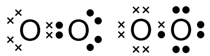
This document consists of **11** printed pages.

Mark schemes will use these abbreviations:

;	separates marking points
/	alternatives
ORA	or reverse argument
ALLOW	for a non-ideal but allowable alternative valid point
NOT	answer is not credited
<u>underline</u>	actual word underlined must be used by candidate (grammatical variants excepted)
(xxx)	wording in brackets is for the clarity of the mark scheme but is not required
max	indicates the maximum number of marks that can be given
+	or **AND** statements on both sides of the **+** or **AND** are needed for that mark
ECF	error carried forward
IGNORE	for an answer that is not creditworthy but does not invalidate any additional creditworthy response

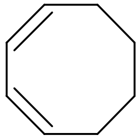
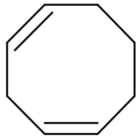
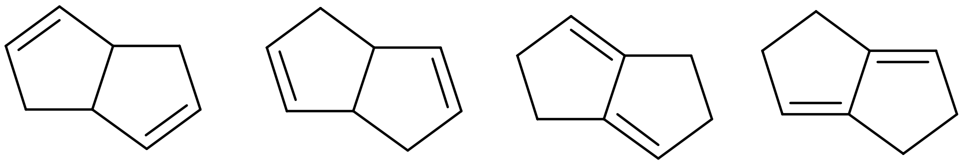
Question	Marking point	Mark
1(a)(i)	Si (2), S (2), Ar (0) All three correct (2) **OR** two correct (1)	**2**
1(a)(ii)	Ar / argon (1)	**1**
1(a)(iii)	$Si(g) \rightarrow Si^{+}(g) + e^{-}$ (1)	**1**
1(b)(i)	$NaCl$: pH7 AND $NaCl$ disappears / dissolves (1) White solid / ppt (formed) for $SiCl_4$ and no mention of ppt with PCl_5 (1) pH given in range 0 to 6 for both $SiCl_4$ and PCl_5 (1) Misty / cloudy / steamy / cloud / fumes / vapour for both $SiCl_4$ and PCl_5 (1)	**4**
1(b)(ii)	$SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl$ (1) $PCl_5 + 4H_2O \rightarrow H_3PO_4 + 5HCl$ (1) Equations must be balanced. Ionic equations are not permissible.	**2**
1(c)	Na_2O: 10–14 (1) P_4O_{10}: 1–6 (1) Accept any value in the range or a range within these values.	**2**

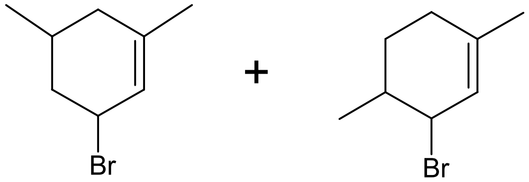
Question	Marking point	Mark
2(a)(i)	Correct dot-cross diagrams for O_2 and O_2^{2-} (1) + (1)  O_2 O_2^{2-}	**2**
2(a)(ii)	(Species) with an <u>unpaired electron</u>(s) (1)	**1**
2(b)(i)	(Enthalpy change) when <u>1 mole</u> of <u>atoms</u> is formed from its <u>element</u> (1) <u>Gaseous</u> (atoms) (1) Element in its standard state **OR** under standard conditions (1)	**3**
2(b)(ii)	(+)249 kJ mol^{-1} (1)	**1**
2(c)	ΔH ($4O_2$) = (–)1992 (kJ mol^{-1}) **and** ΔH(O_8) = (–)1168 (kJ mol^{-1}) (1) O_2 is more exothermic process / more energy released / higher bond energy / more negative / or expressed in terms of breaking O_2 / or expressed in terms of O_8 (1)	**2**
2(d)(i)	$H_2O_2 \rightarrow O_2 + 2H^+ + 2e^-$ species (1) balancing (1)	**2**
2(d)(ii)	Amount of $Cr_2O_7^{2-}$ = (28.5 cm^3 × 0.02 mol dm^{-3} =) 0.00057 mol (1) Amount of O_2 = (0.00057 mol × 3 =) 0.00171 mol (1) Volume of O_2 = (0.00171 mol × 24 000 cm^3 mol^{-1} =) 41.0 cm^3 (1)	**3**

Question	Marking point	Mark
3(a)(i)	Diagram indicating convergence of levels n = 1–4 (1)	**1**
3(a)(ii)	Downward-pointing arrow between any two levels (1)	**1**
3(a)(iii)	No shielding **OR** no electron-electron interaction/repulsion (1)	**1**
3(a)(iv)	$E = 1\,310\,000 / 6.02 \times 10^{23}$ **OR** 2.18×10^{-18} (J) (1) f = ($2.18 \times 10^{-18} / 6.63 \times 10^{-34}$ =) 3.28×10^{15} Hz (1)	**2**
3(b)(i)	Atomic orbitals labelled as 1s (1) Labelled sigma bond / σ **AND** sigma anti-bond / σ* (1) Two electrons shown in lower-energy MO and one in each H 1s orbital (1)	**3**
3(b)(ii)	Full orbital / pair of electrons in σ* / equal number of electrons in σ and σ* **AND** Destabilises molecule **OR** σ* electrons cancel/break bond **OR** explanation that effect is from nuclei pushing apart (1) Bond order = zero (1)	**2**
3(c)	Hydrogen bonds **AND** stronger for H-F (than N-H) (1) F is more electronegative than N **OR** H–F is more polar than H–N (1) Ionic (bonding) / electrostatic forces **AND** stronger for LiC*l* (1) Br^- larger (ionic radii) / smaller charge density than Cl^- / LiBr internuclear distance larger than for LiC*l* / **ORA** (1) <u>Van der Waals / London / dispersion / IDID forces</u> in bromine <u>stronger</u> than <u>H-bonding</u> in NH_3 (1) Larger number of electrons in Br_2 **OR** bromine is more polarisable (1)	**6**

Question	Marking point	Mark
4(a)(i)	Dehydrating agent (1) $C_6H_{12}O_6 \rightarrow 6C + 6H_2O$ (1)	**2**
4(a)(ii)	Oxidising agent (1) $Cu + 2H_2SO_4 \rightarrow CuSO_4 + 2H_2O + SO_2$ (1)	**2**
4(b)(i)	2.5 (1)	**1**
4(b)(ii)	Bond angle 102–106° (102° and 104° actual) (1) Two non-bonded / lone pairs and (two) bonded pairs (1) <u>Non-bonded / lone pairs repel</u> more strongly than the bonded pairs **OR** reducing the bond angle (1)	**3**

Question	Marking point	Mark
5(a)(i)	Enthalpy change when 1 mole of a substance is (1) Completely combusted / combusted in excess oxygen (1) Reference to standard states or standard conditions (1)	**3**
5(a)(ii)	$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ Balanced equation (1) Correct state symbols (1)	**2**
5(b)(i)	Heat absorbed by water = (100 × 4.18 × (58.6 – 21.0) = 15716.8 J =) 15.7 kJ (1) Heat released from combustion = (15.7 × 100 / 65 =) 24.2 kJ (1) (Amount of ethanol = 0.98 g / 46 g mol^{-1} = 0.0213 mol) $\Delta_c H$(ethanol) = (−24.2 kJ / 0.0213 mol = −1134.9 =) –1130 kJ mol^{-1} (1)	**3**
5(b)(ii)	Incomplete combustion (of the ethanol) (1)	**1**
5(b)(iii)	More moles of ethanol calculated compared to the correct value **AND** calculated value less exothermic / less negative / smaller than it would have been (1)	**1**

Question	Marking point	Mark
6(a)(i)	 Q  R One mark for each structure (1) + (1)	**2**
6(a)(ii)	Simplest / lowest whole-number ratio of (atoms of) each element (present in a compound) (1)	**1**
6(a)(iii)	C_2H_3 (1)	**1**
6(a)(iv)	2 peaks (1)	**1**
6(a)(v)	10–35 ppm (1) 115–140 ppm (1)	**2**
6(a)(vi)	Any one of the following (1) 	**1**
6(b)(i)	Addition	**1**

Question	Marking point	Mark
6(b)(ii)	 One mark for each structure (1 + 1)	**2**
6(c)	 One mark for each structure (1) + (1) *trans* 3-methylpent-2-ene **AND** *cis* 3-methylpent-2-ene (1)	**3**
6(d)(i)	Ionisation (1) Acceleration (1)	**2**
6(d)(ii)	**1 mark each for any three of:** (Most) ions are equally charged (1+) (1) Same (kinetic) energy (after acceleration) (1) Ions pass along long tube (where separation occurs) (1) Time taken depends (only) on the mass (1) Heavier ions more move slowly/take longer (to traverse the tube) **ORA** (1)	**3**

Question	Marking point		Mark
7(a)(i)	Filter **and** wash with (distilled) water dry (in a desiccator / an oven)	(1) (1)	**2**
7(a)(ii)	Amount of CaC_2O_4 = (0.565 g / 128.1 g mol^{-1} =) 4.41 × 10^{-3} mol Mass of CaO = (4.41 × 10^{-3} mol × 56.1 g mol^{-1} =) 0.247 g	(1) (1)	**2**
7(a)(iii)	Heat to constant mass	(1)	**1**
7(b)(i)	Amount $S_2O_3^{2-}$ = (25.6 cm^3 × 0.005 mol dm^{-3}) = 1.28 × 10^{-4} mol to react with 250 cm^3 Amount $S_2O_3^{2-}$ = 4 × 1.28 × 10^{-4} mol = 5.12 × 10^{-4} mol to react with 1000 cm^3 (Amount I_2 = 2.56 × 10^{-4} mol in 1000 cm^3) Amount Mn^{2+} = 5.12 × 10^{-4} mol in 1000 cm^3 Amount O_2 = 1.28 × 10^{-4} mol in 1000 cm^3 (Mass O_2 = 1.28 × 10^{-4} mol × 32 g mol^{-1} = 4.096 × 10^{-3} g in 1000 cm^3) Mass O_2 = 4.10 × 10^{-3} g dm^{-3} **AND** river is unhealthy If final answer is >6 × 10^{-3} g dm^{-3} then allow conclusion that river is healthy.	(1) (1) (1) (1) (1) 3.s.f required	**5**
7(b)(ii)	Starch Blue-black to colourless Towards / close to the end-point of the titration / when the solution goes yellow / straw-coloured	(1) (1) (1)	**3**

Question	Marking point	Mark
8(a)	Polystyrene / any plastic / insulated cup (+ lid) (1) Initial temp and final temp (1) Stated volume of $CuSO_4$ + use a measuring cylinder / burette / pipette (1) Calculate moles of $CuSO_4$ and mass of Zn to use, based on a 1:1 mole ratio (1) Indication which reagent is used in excess **OR** which reagent is limiting (1) Stir throughout reaction (to increase rate) (1)	**6**
8(b)	Use $q = mc\Delta T$ (to calculate energy released) **AND** indicate that m is the mass of the solution / water heated (1) Use of $\Delta H = -q / n$ to calculate enthalpy change per mole **AND** make clear that n is the amount of the limiting reagent (1)	**2**