UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

Pre-U Certificate

MARK SCHEME for the May/June 2010 question paper

for the guidance of teachers

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 must be read in conjunction with the question papers and the report on the examination.

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UNIVERSITY of CAMBRIDGE
International Examinations

1 **(a)** ethanol: 46 g mol^{-1}
octane: 114 g mol^{-1}
1 mark if both numbers correct
no penalty for incorrect sig. figs. [1]

(b) density in g cm^{-3} = 2 g mol^{-1} / 24000 cm^3 mol^{-1} = 8.3×10^{-5} g cm^{-3}
no penalty for incorrect sig. figs. [1]

(c) zero (by definition)
award this mark if the zero is just entered in the table [1]

(d) –285.8 kJ mol^{-1}
the mark is given for indicating that it is the same as the enthalpy of formation given in the question [1]

(e) $C_8H_{18}(l) + 25/2O_2(g) \rightarrow 8CO_2(g) + 9H_2O(l)$ (1)
equation must be per mole of octane and correctly balanced for the first mark
correct state symbols for octane, oxygen, carbon dioxide and water (1) [2]

(f) Δ_cH^e (octane) = $8\Delta_fH^e$ (CO_2) + $9\Delta_fH^e$ (H_2O) – Δ_fH^e (octane)
= {(8 × –393.5) + (9 × –285.8) – (–250)} kJ mol^{-1}
= {–3148.0 – 2572.2 + 250.0} kJ mol^{-1}
= –5470.2 kJ mol^{-1} (3)
$\Delta_fH^e(CO_2)$ and $\Delta_fH^e(H_2O)$ multiplied by 8 and 9, respectively (1)
correct signs (1)
2 marks given if all correct apart from an arithmetical slip
2 marks given for 5470.2 kJ mol^{-1} [max 3]

(g) **(i)** methanol: –726.0 kJ mol^{-1} / 32 g mol^{-1} = –22.69 kJ g^{-1} [1]

(ii) hydrogen: –285.8 kJ mol^{-1} / 2 g mol^{-1} = –142.9 kJ g^{-1}
accept from 2 to 5 sig. figs.
no penalties for missing units or forgetting minus sign
–1 for each wrong answer
–1 if sig. figs. outside the allowed range (only penalise once) [1]

(h) **(i)** ethanol: –1367.3 kJ mol^{-1} × 0.789 g cm^{-3} / 46 g mol^{-1}
= –23.5 kJ cm^{-3} [1]

(ii) octane: –5470.2 kJ mol^{-1} × 0.703 g cm^{-3} / 114 g mol^{-1}
= –33.7 kJ cm^{-3}
accept only 2 or 3 sig. figs.
no penalties for missing units or forgetting minus sign
–1 for each error
–1 if sig. figs. outside the allowed range (only penalise once)
where working is correct but final answer is inexplicably wrong, allow the mark [1]

(i) the enthalpy change of combustion value for hydrogen is for standard conditions, and so relates to gaseous hydrogen, not to liquid hydrogen
OR no account taken of different temperatures / latent heat of vaporisation of hydrogen
allow comment about how the value of the density of liquid hydrogen is unsuitable for the calculation of energy per unit volume for gaseous hydrogen
allow just a reference to the different state of hydrogen [1]

[Total: 14]

2 **(a)** 178/(178 + 32) × 100% = 84.8% [1]

(b) correct plotting of point in van Arkel triangle (1)
the point has coordinates (2.39, 2.45) half a gradation of leeway either side, i.e. 0.05 on the scale, is acceptable
it is an insulator (1) [2]

(c) it is ionic [1]

(d) reaction 1: $HfO_2 + 4HCl \rightarrow HfCl_4 + 2H_2O$ (1)
reaction 2: $HfCl_4 + 2Mg \rightarrow Hf + 2MgCl_2$ (1)
ecf incorrect hafnium chloride formula in step 2 from step 1 [2]

[Total: 6]

3 **(a)** CsF [1]

(b) clear that a Cs electron is in the F outer shell (1)
charges shown on the ions (1)
allow a Cs ion with 8 electrons shown in the outer shell
no marks awarded if there is sharing of electrons [2]

(c) largest possible difference in electronegativity between its two constituent elements owtte [1]

(d) high boiling point / low vapour pressure / does not evaporate easily [1]

(e) wide separation of charges / large ions AND low charges both needed for mark [1]

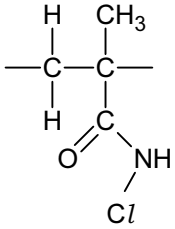
(f) high surface tension (1)
(relatively) high melting and/or boiling points or liquid at rtp (compared to analogous compounds) or high specific thermal capacity (1)
less dense as a solid than as a liquid (owtte) or greatest density at 4° C (1) [max 2]

(g) H bond drawn between hydrogen on one molecule and oxygen on another (1)
oxygen lone pair drawn at the start of one of the H bonds and both ends of a dipole shown on each molecule (1)
bond angle of 180° around an H-bonding hydrogen – shown explicitly or looks like 180° intended (1) [3]

(h) two H bonds shown between two amine groups on melamine and the carbonyl oxygens on PTCDI, and an H bond shown between the NH group on the PTCDI and the –N= atom on melamine that is between the two H-bonding amine groups. (2)
for both marks the H-bonds from the amine groups must be from one of the two hydrogens of each amine in particular, rather than just from $–NH_2$ otherwise just 1 mark is given
ecf from **(g)** if the notation for an H-bond is incorrect
no marks if all three H bonds aren't correctly identified
small errors in copying down the structures should not be penalised as long as they don't affect the H-bonding interaction [2]

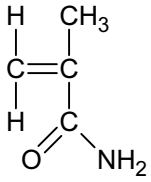
[Total: 13]

4 **(a)** allow either the repeat fragment or the notation with it in brackets
brackets must be used if a skeletal formula is used to represent the repeat unit
only two carbons in the backbone should be shown in the fragment or between the brackets
allow any unambiguous structural formula



[1]

(b) the monomer should show a C=C double bond between the two backbone carbons from the repeat unit, and an amide in place of the N-chloroamide
the C=C double bond must be explicit rather than implied



[1]

(c) **(i)** (+)1 [1]

(ii) (+)1
ecf from **(c)(i)**, i.e. answer to **(c)(ii)** should be the same as **(c)(i)** [1]

(iii) oxidation: $2I^- \rightarrow I_2 + 2e^-$ (1)
reduction: $ClO^- + 2H^+ + 2e^- \rightarrow Cl^- + H_2O$
or $HOCl + H^+ + 2e^- \rightarrow Cl^- + H_2O$ (1) [2]

(iv) starch [1]

(v) 12.50 cm^3 × 0.100 mol dm^{-3} = 0.00125 mol
no sig. figs. or unit penalties [1]

(vi) 0.00125 mol / 2 = 0.000625 mol
no sig. figs. or unit penalties
ecf from **(v)**, i.e. answer from **(v)** should be divided by 2 [1]

(vii) 0.000625 mol × 35.5 g mol^{-1} × 100 cm^3 / 10 cm^3 = 0.222 g (2)
1 mark for multiplying answer to **(vi)** by 35.5 g mol^{-1}
1 mark for scaling up by 10, even if this isn't explicitly explained.
no sig. figs. or unit penalties
ecf from **(i)** [2]

[Total: 11]

5 **(a)** 292 – 122 = 170 [1]

(b) 9 [1]

(c) 18
ecf from part **(b)**, i.e. the number of elements wide = twice the number of orbitals [1]

(d) 4p 5s 4d 5p 6s 4f 5d [1]

(e) 6d, 7p, 8s and 5g should be added to the diagram as below [1]

1s	2s	3s	4s	5s	6s	7s	**8s**
	2p	3p	4p	5p	6p	**7p**	
		3d	4d	5d	**6d**		
			4f	5f			
				5g			

(f) two *g* electrons [1]

[Total: 6]

6 **(a)** 5 signals [1]

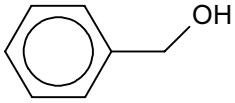
(b) 3 isomers [1]

(c) any oxidising agent, e.g. manganate, dichromate, chlorate
ignore omission of acidification where necessary
oxidising agents that lack an oxygen atom need to be indicated as (aq)
if a formula is given it must be correct to earn the mark
if an oxidation number is quoted it must be correct to earn the mark [1]

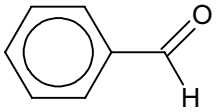
(d) Grignard (reagent) [1]

(e) 1: (nucleophilic) substitution allow hydrolysis (1)
5: hydrolysis (1)
6: dehydration / elimination allow reduction as FGL of functional group carbon has decreased by 1 (1) [3]

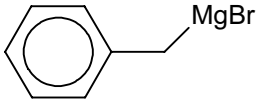
(f) A: benzyl alcohol (phenylmethanol) (1)



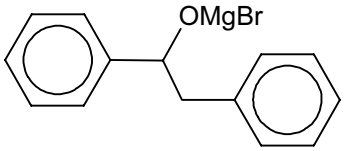
B: benzaldehyde (1)



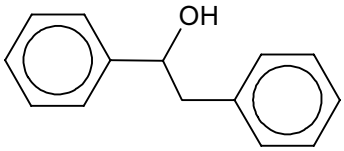
C: benzylmagnesium bromide (1)



D: $PhCH(OMgBr)CH_2Ph$ (1)



E: $PhCH(OH)CH_2Ph$ (1)



allow all structural and displayed formulae as long as structure is unambiguous
penalise repeated systematic or trivial errors only once [5]

[Total: 12]

7 **(a)** $\delta+$ on the I and $\delta-$ on the N
OR correct use of arrow nomenclature [1]

(b) **(i)** $NH_3 + 3F_2 \rightarrow NF_3 + 3HF$ [1]

(ii) $2NF_3 \rightarrow N_2 + 3F_2$ or with stoichiometry 1:1/2:3/2 [1]

(iii) correct dot-cross diagram, including lone pairs on the fluorines (1)
shape = pyramidal (or trigonal pyramidal) (1)
bond angle indicated as anything from 102 to 107° (1)
(actual bond angle is 102.3 degrees: there is weak bonding pair-bonding pair repulsion due to the electron density in the N–F bonds being shifted towards the electronegative fluorine atoms) [3]

(iv) stronger N–F bonds / higher activation energy
allow: since the F–F bond is weaker than the C*l*–C*l* bond the thermal decomposition of NF_3 will be less exothermic than for NCl_3 [1]

(c) **(i)** $N_2O_5 + H_2O \rightarrow 2HNO_3$ [1]

(ii) $12HNO_3 + P_4O_{10} \rightarrow 6N_2O_5 + 4H_3PO_4$ (2)
accept $6HNO_3 + P_2O_5 \rightarrow 3N_2O_5 + 2H_3PO_4$
1 mark for correct formulae but incorrect balancing [2]

(iii) $NO_2^+ NO_3^-$ or NO_2NO_3 [1]

[Total: 11]

8 **(a)** cis (or Z) [1]

(b) ictadeca-6,9,12,15-tetraenoic acid
accept tetrenoic instead of tetraenoic
accept without the hyphens or with hyphens instead of commas. [1]

(c) $2^5 = 32$ geometric isomers [1]

(d) instantaneous dipole – induced dipole forces [1]

(e) the 3rd from last carbon atom from the COOH functional group is the final one in a C=C double bond (owtte) [1]

(f) $BrCH_2CHBrCH_3$ (1)
accept any unambiguous structure that is correct.
1,2-dibromopropane (1)
don't penalise errors with commas, spaces or hyphens [2]

(g) (i) amount of C=C bonds in 100 g = 6 × 100 g / 328 g mol^{-1} = 1.83 mol (1)
mass of iodine required = 1.83 mol × 254 g mol^{-1} = 465 g (1)
ecf for second mark if correct calculation with wrong number of C=C bonds.
1 mark lost for not quoting final answer to 3 or 4 sig. figs.
no penalties for missing units [2]

(ii) oleic acid $C_{18}H_{34}O_2$ [1]

(h) (i) the I–C*l* bond has a (permanent) dipole [1]

(ii) use of cervonic acid in calculation (as it reacts with the most IC*l*) (1)
vol of 25% excess IC*l*
= 1.25 × (6 × 0.100 g / 328 g mol^{-1}) / 0.100 mol dm^{-3} = 22.9 cm^3 (1)
give this mark if a correct calculation has been performed with another fatty acid.
excess IC*l* to be used = 25.0 cm^3 (1)
ecf for rounding up the volume of IC*l* to a pipette size (10 cm^3, 20 cm^3 or 50 cm^3)
transferred using a pipette (1) [4]

(iii) transfer sample directly to stoppered flask (1)
250 cm^3 flask (1)
transfer using 1,1,1-trichloroethane washings (1)
leave for 30 minutes after adding Wijs' reagent (1)
measuring cylinder used for adding KI (1)
measuring cylinder used for adding water (1)
$Na_2S_2O_3$ dispensed from a burette or use of the word "titrate" or "titration" (1)
starch indicator (1)
blue-black to colourless (1)
white tile (1)
shaking of (stoppered) flask after $Na_2S_2O_3$ additions ("swirling" not enough) (1)
working with 1,1,1-trichloroethane in a fume cupboard (1) [max 8]

(iv) vol $Na_2S_2O_3$(aq) × 0.100 mol dm^{-3} = amount $Na_2S_2O_3$(aq) (1)
amount $Na_2S_2O_3$(aq) = 2 × amount IC*l* (excess) (1)
amount IC*l* (reacted) = amount IC*l* (initial) – amount IC*l* (excess) (1)
compare this amount IC*l* (reacted) with n(C=C bonds) × 0.100 g / molar mass for each fatty acid (in order to identify the fatty acid, which will be the one that most closely resembles the experimental value.) (1)
loss of 1 mark for confusing I_2 with IC*l*. [4]

[Total: 27]