CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge Pre-U Certificate

MARK SCHEME for the May/June 2015 series

9791 CHEMISTRY

9791/02 Paper 1 (Part A Written), maximum raw mark 100

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

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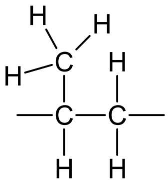
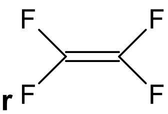
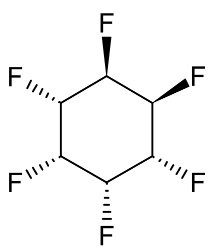
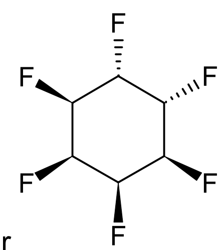
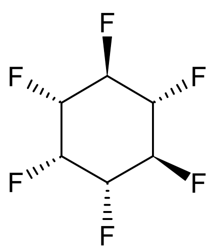
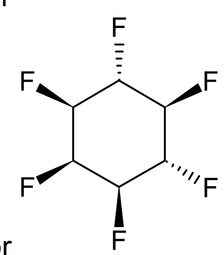
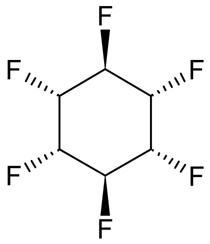
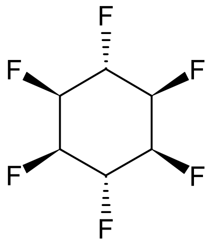
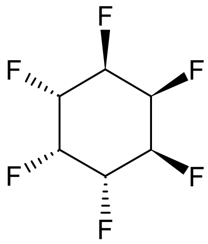
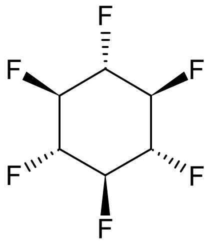
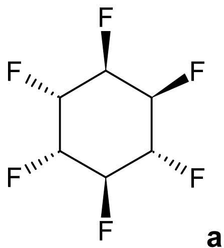
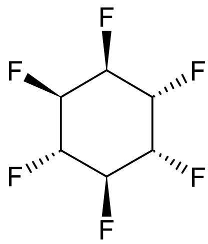
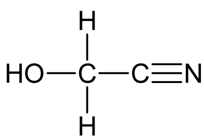
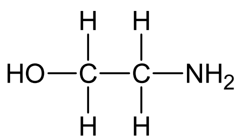
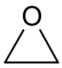
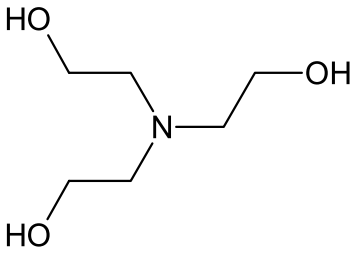
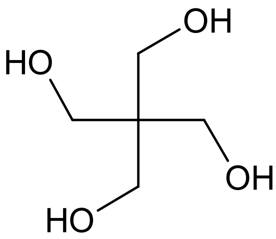
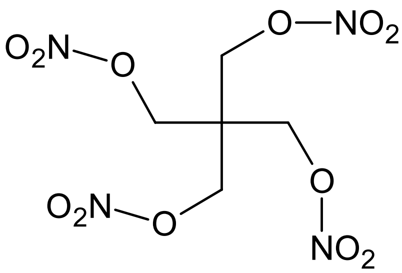
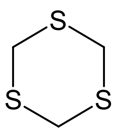
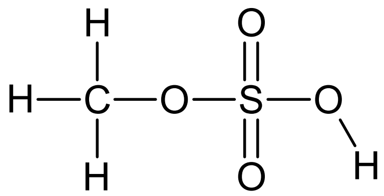
CAMBRIDGE
International Examinations

1 (a) (i)	Forming <u>one mole</u> of substance / compound From its <u>elements</u> In their standard states **or** under standard conditions	1 1 1
(ii)	$\Delta_c H^\circ$ (298 K) = {−393.5 + 2×(−285.8) – (−74.8)} kJ mol^{-1} = −890.3 kJ mol^{-1} Doubling the enthalpy for water Subtraction of reactant enthalpies from product enthalpies	 1 1
(b) (i)	$\Delta_r H^\circ$ = {(4×435) + (2×464) − 1077 – (3×436)} kJ mol^{-1} = +283 kJ mol^{-1} Correctly multiplying the energies by stoichiometric ratios. Subtracting product energies from reactant energies.	 1 1
(ii)	**Either**: large activation energy (1) as strong bonds must be broken (1) **Or**: forward reaction promoted (1) as it is endothermic (1)	1 1
(c) (i)	$3CO + 6H_2 \rightarrow C_3H_6 + 3H_2O$	1
(ii)	 Dangling bonds required, but penalise if on the methyl group.	1
(d) (i)	S_8 (The 8 must be subscripted.)	1
(ii)	Oxidising agent	1
(iii)	(2 × methane equation) minus ethene equation gives +101 kJ mol^{-1} Subtracting ethene equation / energy from methane equation / energy Doubling methane equation / energy	 1 1
(iv)	CS_2 is linear H_2S is bent / V-shaped / non-linear	1 1
		[Total: 17]
2 (a) (i)	Mass = 0.50 g × (58.5 / 23) = 1.3 g (1.27 g)	1
(ii)	Mass conc of Na^+ = 23 g mol^{-1} × 0.50 mol dm^{-3} = 11.5 g dm^{-3} Volume = 0.50 g / 11.5 g dm^{-3} = 43 cm^3 (43.5 cm^3)	1 1
(b) (i)	Volume = ½ × 24 dm^3 mol^{-1} × 1.50 g / 58.5 g mol^{-1} = 0.31 dm^3 2:1 stoichiometry for sodium chloride: chlorine taken into account. Correct use of molar volume and molar mass. Mark not awarded if answer not given to 2 sig figs.	 1 1
(ii)	pH 7	1
(iii)	Blue / purple colour **and** $2Na + 2H_2O \rightarrow 2NaOH + H_2$	1
(c)	Red colour <u>Polarising</u> Al^{3+}(aq) weakens O–H bond OR stabilises coordinated OH^- ion **or**	1

	leads to dissociation of $H^+(aq)$ (from coordinated water molecules). $[Al(H_2O)_6]^{3+}(aq) \rightarrow [Al(H_2O)_5OH]^{2+}(aq) + H^+(aq)$	1 1
(d) (i)	$2NaOH + Cl_2 \rightarrow NaClO + NaCl + H_2O$ Chlorate(I)	1 1
(ii)	$Cl_2O + H_2O \rightarrow 2HOCl$	1
		[Total: 13]
3 (a) (i)	No. protons = 92. No. neutrons = 143. No. electrons = 92	1
(ii)	(Weighted) average mass Masses are relative to 1/12 of (the mass of a neutral atom of) carbon-12.	1 1
(iii)	Relative atomic mass = (0.007×235) + (0.993×238) = 238.0 Final answer given to 1 decimal place	1 1
(b) (i)	$1s^2 2s^2 2p^5$ The superscripting must be correct.	1
(ii)	**Either**: U−F dipoles cancel out (in an octahedral molecule) **Or**: δ− charges of F atoms cause repulsion between molecules **Or**: fluorine has low polarisability.	1
(iii)	$F_2C{=}CF_2$ **or** 	1
(c) (i)	Consistent: F_2 Inconsistent: HF	1 1
(ii)	Consistent: H−F or C−F Inconsistent: F_2	1 1
(d) (i)	Addition **or** reduction	1
(ii)	Pentanal	1
(e) (i)	1,2 isomer:  or  1,3 isomer:  or 	

	1,4 isomer:  **or**  Two marks for all three structures correct; one mark for two structures correct.	2
(ii)	1,2,3 isomer: 	1
	1,3,5 isomer: 	1
	1,2,4 isomer and its enantiomer:  **and** 	1
	Enantiomers correctly identified.	1
(iii)	9 isomers altogether.	1
		[Total: 21]
4 (a) (i)	Carbonyl, **accept** FGL2	1
(ii)	Methanol / CH_3OH	1
(b) (i)	**C** is 	1
(ii)	**D** is 	1

(c) (i)	**E** is 	1
(ii)		1
(d)	**B** is 	1
(e) (i)	PETN is 	1
(ii)	Water	1
(f) (i)	$3HCHO + 3H_2S \rightarrow C_3H_6S_3 + 3H_2O$	1
(ii)	**F** is  **Allow** cyclopropane with an SH on each carbon. **Allow** a triangle of sulfurs, each bonded to $=CH_2$. **Allow** alternating single and double bonds around ring and an H bonded to each sulfur.	1
(g)	$C_2H_5Br + Mg \rightarrow C_2H_5MgBr$ (1) $C_2H_5MgBr + HCHO \rightarrow C_2H_5CH_2OMgBr$ (1) $C_2H_5CH_2OMgBr + H^+ \rightarrow C_2H_5CH_2OH + Mg^{2+} + Br^-$ (1) $C_2H_5CH_2OH + [O] \rightarrow C_2H_5CHO + H_2O$ (1) Suitable oxidising agent, eg acidified sodium or potassium dichromate, (to oxidise propan-1-ol to propanal). (1) <u>Dry ether</u> solvent for preparing or reacting Grignard reaction. (1) Oxidising agent added dropwise. (1) (Propanal recovered by) <u>distilling</u> (oxidation reaction). (1) **[Max: 7]**	7
		[Total: 18]

5 (a) (i)	C_5H_5N	1
(ii)		1
(b) (i)	3 (mol)	1
(ii)	Acid-base (as pyridine is a base and HI is an acid) / neutralisation	1
(iii)	Yellow indicates (a trace of) iodine past the end-point	1
(iv)	To ensure reaction with water goes to completion.	1
(c)	Atom oxidised is S and atom reduced is I. S goes from ox no. +4 to +6. I goes from ox no. 0 to −1.	1 1 1
(d) (i)	M1: Mass of I_2 required = 0.2500 dm^3 × 50.0 g dm^{-3} = 12.5 g (1) M2: Stoichiometric amount of Py = 3 × 0.2500 dm^3 × 0.197 mol dm^{-3} = 0.148 mol(1) M3: Stoichiometric volume of Py = 0.148 mol × 80 cm^3 mol^{-1} = 12 cm^3 (1) M4: Actual volume of Py chosen to be at least 12 cm^3 (1) M5: Measure I_2 and Py with scales / a (mass) balance and a measuring cylinder, respectively. (1) M6: Dissolve I_2 and Py in the methanol(/ SO_2) solution in a beaker. (1) M7: Transfer to a 250 cm^3 volumetric flask with washings.(1) M8: Make up to the mark / line with the methanol / SO_2 solution. (1) M9: Invert / mix.(1) **[Max 7 marks from M1 – M9]** M10: Prepare the Fischer reagent in a fume cupboard.(1) M11: Avoid naked flames / Bunsen burners(1) **[Max 8 marks total]**	8
(ii)	React iodine with (excess sodium) thiosulfate. Transfer methanol to a solvent residues bottle **Or** pour methanol down the sink with (plenty of) water	1 1
(iii)	M1: Transfer sample solution to a conical flask. (1) M2: Use a 25 cm^3 pipette to transfer the sample solution. (1) M3: Transfer the Fischer reagent to a burette. (1) M4: Place a white tile beneath the conical flask **or** swirling conical flask during addition from burette. (1) M5: Titrate <u>dropwise approaching endpoint</u> until end-point is reached **or** until (the first permanent) pale yellow colour is seen. (1) M6: Repeat until concordant / consistent titres are obtained. (1) **[Max 5]**	5
(iv)	The methanol wasn't dry **or** methanol is hygroscopic **or** methanol absorbed water from the air.	1
(v)	Conc of I_2 = 50.0 g dm^{-3} / 254 g mol^{-1} = 0.197 mol dm^{-3} **or** Amount of I_2 = 0.05 g / 254 g mol^{-1} = 1.97 × 10^{-4} mol. Consumption of water = 18000 mg mol^{-1} × 0.000197 mol cm^{-3} = 3.54 mg cm^{-3}	1

	or Mass of water = 1.97×10^{-4} mol × 18 g mol^{-1} = 0.00354 g = 3.54 mg **Alternatively**, the calculation may be done in reverse to show that 3.54 mg of water corresponds to 1 cm^3 of 50.0 g dm^{-3} I_2 (aq): Amount of water = 3.54 mg / 18 g mol^{-1} = 1.97×10^{-4} mol Mass of iodine = 1.97×10^{-4} mol × 254 g mol^{-1} = 0.05 g Conc of I_2 = 0.05 g / 0.001 dm^3 = 50 g dm^{-3}	1
(vi)	M1: Vol of Fischer reagent that reacts with sample = 12.55 cm^3 – 2.20 cm^3 = 10.35 cm^3. M2: Mass of water in tartrate sample in titration = 3.54 mg cm^{-3}×10.35 cm^3 = 36.67 mg. M3: Mass of anhydrous sodium tartrate in total tartrate sample = 2.344 g – (10 × 0.03667 g) = 1.977 g. M4: *x* = amount of water / amount of anhydrous sodium tartrate in total sample = (0.3667 g / 18 g mol^{-1}) / (1.977 g / 194 g mol^{-1}) = 2.00 = 2 (<u>integer required</u>) M3 & M4 could be based on the quantities in the titration, in which case the 2.344 g would need to be divided by 10 instead of the 0.03667 g being multiplied by 10. **Alternative** (longer) method: Mass of I_2 = 50.0 g dm^{-3} × 0.01035 dm^3 = 0.5175 g Amount of I_2 = 0.5175 g / 254 g mol^{-1} = 0.0020374 mol M2: Amount of water = amount of I_2 = 0.0020374 mol (1) Mass of water in titration = 0.0020374 mol × 18 g mol^{-1} = 0.03667 g M3: Mass of total tartrate = 2.344g – (10 × 0.03667 g) = 1.977 g(1) M1 & M4 are the same as in the first method.	1 1 1 1
		[Total: 31]