CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Level

MARK SCHEME for the October/November 2014 series

9701 CHEMISTRY

9701/41 Paper 4 (A2 Structured Questions), 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

Question	Marking point	Marks	Marks total
1 (a) (i)	[NO] 2^{nd} order **and** the concentration is ×2, rate × 4 $[O_2]$ 1^{st} order **and** evidence of using expt 1 & 2 when the concentration is ×2, rate doubles	**1** **1**	
(ii)	(0.00408 × 27) rate = **<u>0.11</u>** (mol dm^{-3} s^{-1}) to **2sf**	**1**	
(iii)	(Rate =) k $[O_2][NO]^2$	**1**	
(iv)	k = 332(.03125) mol^{-2} dm^6 s^{-1}	**1** **1**	**[6]**
(b) (i)	labelled axes x-axis: energy (KE) and y-axis: molecules or particles two curves: starts origin; not touching x-axis again; no levelling out; curves only intersecting once curves labelled and T2 is to the right and lower max than T1	**1** **1** **1**	
(ii)	rate increases **and** energy of the particles increases more particles have E_a	**1** **1**	**[5]**
(c)	1 mole of F_2 and 1 mole NO reacting in the **slow** step a balanced mechanism consistent with overall equation e.g. $F_2 + NO \rightarrow NOF + F$ **OR** $F_2 + NO \rightarrow NOF_2$ $NO + F \rightarrow NOF$ $NO + NOF_2 \rightarrow 2NOF$	**1** **1**	**[2]**
Total			**[13]**

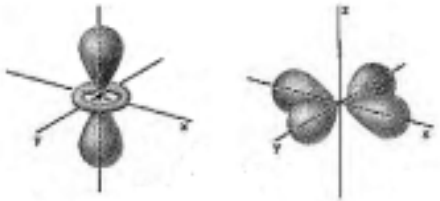
2 (a)

	3d					4s	
(Ni)	↑↓	↑↓	↑↓	↑	↑	↑↓	**1**
(Ni^{2+})	↑↓	↑↓	↑↓	↑	↑		**1** **[2]**

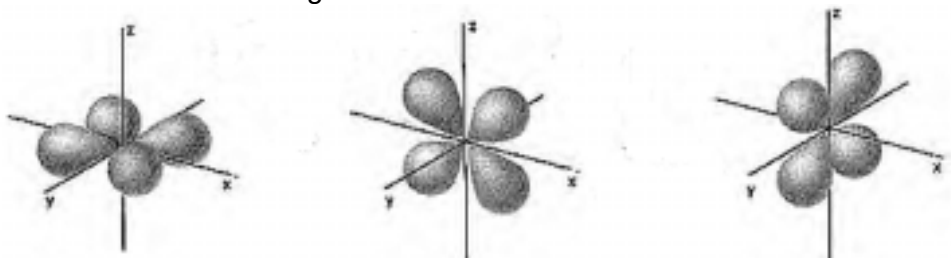
(b) (i) degenerate — **1**

(ii) 2 upper orbitals **and** 3 lower orbitals — **1**

(iii) **correct upper** orbital diagram — **1**



correct lower orbital diagram — **1** **[4]**

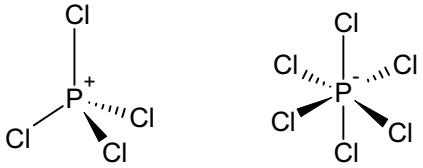
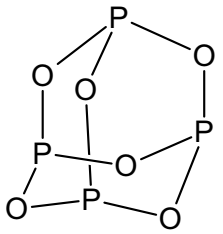
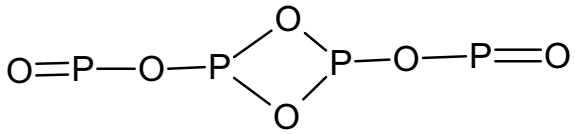


(c) **electron(s)** move from lower to upper level — **1**

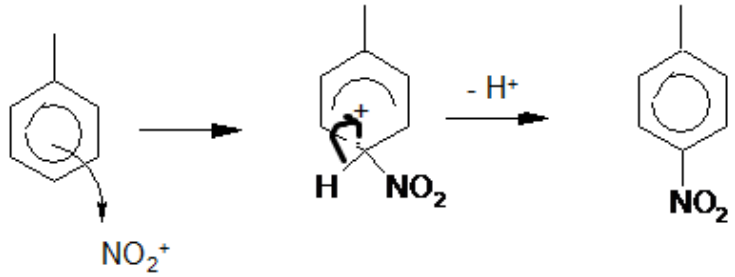
absorb (red/blue) light/photon — **1**

complementary colour (green) is seen
OR green light is transmitted — **1** **[3]**

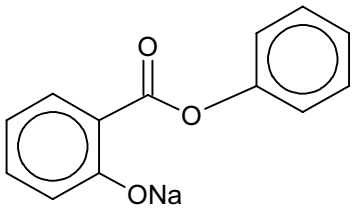
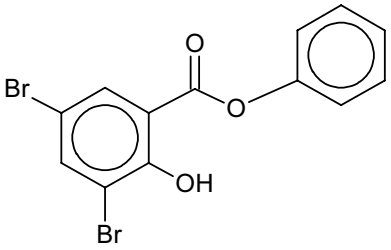
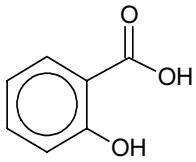
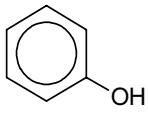
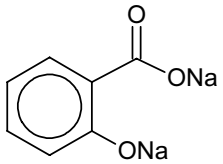
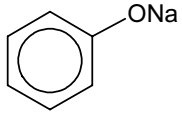
(d)	**A** $Ni(OH)_2$ **OR** $Ni(OH)_2(H_2O)_4$ **B** $[Ni(NH_3)_6]^{2+}$ **OR** $[Ni(NH_3)_n(H_2O)_{6-n}]^{2+}$ **OR** $[Ni(NH_3)_n(H_2O)_{4-n}]^{2+}$ $Ni^{2+} + 2OH^- \rightarrow Ni(OH)_2$ **OR** $[Ni(H_2O)_6]^{2+} + 2OH^- \rightarrow Ni(OH)_2 + 6H_2O$ **OR** $[Ni(H_2O)_6]^{2+} + 2NH_3 \rightarrow Ni(OH)_2 + 4H_2O + 2NH_4^+$ **OR** $[Ni(H_2O)_6]^{2+} + 2OH^- \rightarrow Ni(OH)_2(H_2O)_4 + 2H_2O$ $Ni(OH)_2 + 6NH_3 \rightarrow [Ni(NH_3)_6]^{2+-} + 2OH^-$ **OR** $Ni(H_2O)_6]^{2+} + 6NH_3 \rightarrow [Ni(NH_3)_6]^{2+-} + 6H_2O$	**1** **1** **1** **1**	**[4]**
Total			**[13]**

3	**(a) (i)**	101 = $P^{35}Cl^{35}Cl$ 103 = $P^{35}Cl^{37}Cl$ 105 = $P^{37}Cl^{37}Cl$	**1** **1** **1**	
	(ii)	9:6:1	**1**	**[4]**
	(b) (i)	PCl_5 5 bonding pairs around P	**1**	
	(ii)		**1** **1**	**[3]**
	(c) (i)	 P_4O_6 structure where each P has three P-O bonds and each O has two P-O bonds e.g. 	**1**	
	(ii)	(molecule/ion/species) that **donates** a lone pair of electrons (to a central transition metal atom or ion)	**1**	**[2]**
	(d) (i)	$K_{sp} = [Ca^{2+}]^3[PO_4^{3-}]^2$	**1**	

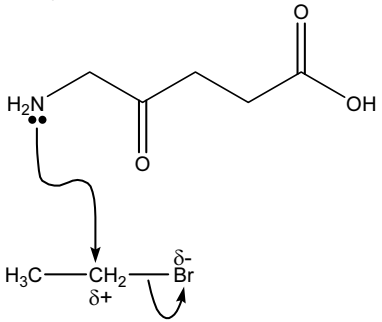
(ii)	$[Ca^{2+}] = 3 \times 2.50 \times 10^{-6} = 7.50 \times 10^{-6}$ mol dm^{-3} $[PO_4^{3-}] = 2 \times 2.50 \times 10^{-6} = 5.00 \times 10^{-6}$ mol dm^{-3} $= (7.50 \times 10^{-6})^3(5.00 \times 10^{-6})^2$ $=$ **1.05(1.1)** $\times$ **10^{-26}** mol^{5}dm^{-15}	**1** **1** **1**	**[4]**
(e) (i)	(enthalpy change) when **1 mole** of an **ionic compound** is **formed** from its **gaseous ions**	**1** **1**	
(ii)	Mg^{2+} has a smaller (ionic) radii than Ca^{2+} **OR** Mg^{2+} is smaller than Ca^{2+}	**1**	**[3]**
Total			**[16]**
4 (a) (i)	$2H_2SO_4 + HNO_3 \rightarrow 2HSO_4^- + NO_2^+ + H_3O^+$ **OR** $H_2SO_4 + HNO_3 \rightarrow HSO_4^- + NO_2^+ + H_2O$	**1**	

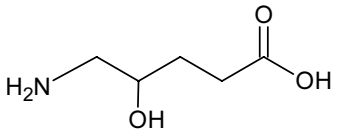
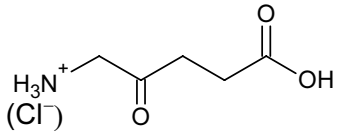
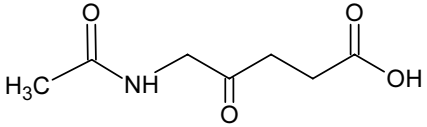
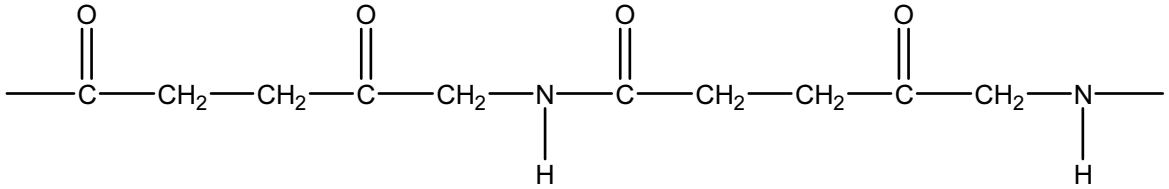
(ii)	**any three** of • curly arrow from inside the benzene ring to NO_2^+ group • intermediate – **penalise** NO_2 connectivity ***or*** missing methyl group (once) • curly arrow from C-H bond into ring • product + H^+ (or as diagram $–H^+$) **allow** 2- and 3-substituted nitromethylbenzene)  	**3**	**[4]**
(b) (i)	acidity of $ClCH_2CO_2H > CH_3CO_2H$ **AND** ($ClCH_2CO_2H$) as an electronegative/electron withdrawing Cl	**1**	
(ii)	acidity of phenol > CH_3CH_2OH **AND** electrons on oxygen (on phenol) delocalised into ring **OR** benzene ring withdraws electrons from oxygen	**1**	
	stronger acid linked to weakening O-H bond/anion being stabilised	**1**	**[3]**

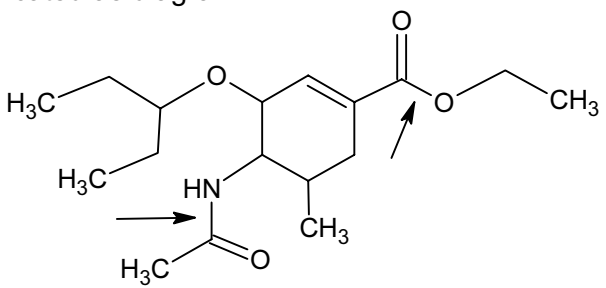
(c)

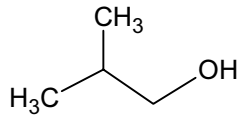
Na	 (or ionic)	redox/reduction
Br_2		(electrophilic) substitution
NaOH	 and  [1] or ionic  	hydrolysis/ acid-base/

1 mark for each correct structure **4**
for reaction types, 2 correct = 1 mark, 3 correct = 2 marks **2** **[6]**

Total			**13**
5 (a)	CH_3CH_2COCl > $CH_3CH_2CH_2Cl$ > C_6H_5Cl **any two** *of:* • C-Cl bond strength is weakest in CH_3CH_2COCl ora • In C_6H_5Cl (no hydrolysis) C-Cl bond is part of delocalised system **OR** p-orbital on Cl overlaps with π system **OR** electrons from Cl overlap with π system • CH_3CH_2COCl carbon in C-Cl bond is more electron deficient since it is also attached to an oxygen atom ora	**1** **1+1**	**[3]**
(b)	ketone, amine, carboxylic acid two correct 1 mark, all three 2	**2**	**[2]**
(c) (i)	dipole on C-Br curly arrow breaking C-Br bond curly arrow from **lone pair** on N to carbon in C-Br bond 	**1** **1** **1**	
(ii)	nucleophilic substitution	**1**	
(iii)	HBr or hydrogen bromide	**1**	**[5]**

(d)	**Y =**  **W =**  **X =**  each structure 1 mark	**3**	**[3]**
(e)	 correct displayed amide formula correct polyamide with two repeat units	**1** **1**	**[2]**
Total			**15**
6 (a)	• (move in different directions) some amino acids have a different charge • (move at different speeds) some amino acids have a different size/different charge • (some amino acids do not move at all) some amino acids exist as a zwitterions/have no net(overall) charge/neutral/both NH_2/COOH are charged in amino acids	**1** **1** **1**	**[3]**
(b) (i)	mobile – solvent ***or*** water stationary – alumina/silica (supported on glass/plastic/Al)	**1** **1**	
(ii)	by adsorption	**1**	**[3]**

(c)	**any three** of: (all can be awarded from a clear, labelled diagram) • (base pairing) A to T **OR** C to G • H-bonds between bases • two/double stranded/chains • anti-parallel strands • (general structure) sugar-phosphate backbone **OR** BASE-SUGAR-PHOSPHATE bonded in a diagram	**3**	**[3]**
(d)	van der Waals' forces lost (in val) H-bonding gained (in ser)	**1** **1**	**[2]**
Total			**11**
7 (a)	amide group circled **OR** indicated as diagram ester group circled **OR** indicated as diagram 	**1** **1**	**[2]**
(b)	lower doses of the drug required **OR** improved activity of the drug **OR** reduced side effects	**1**	**[1]**

(c)	decreases enzyme activity **OR** decreases rate at which product is formed binds with the enzyme's active site **OR** has a complementary shape to active site **OR** similar shape to substrate (competitive inhibition can be overcome by) increasing [substrate] **OR** increasing substrate concentration	**1** **1** **1**	**[3]**
(d)	**energy** source/carrier **OR** releases energy when hydrolysed	**1**	**[1]**
Total			**7**
8 (a)	M:M+1 = 100/(1.1 x n) 20.4/0.9 = 100/(1.1 x n) x =4	**1** **1**	
(ii)	$C_4H_{10}O$	**1**	**[3]**
(b) (i)	2-methylpropan-1-ol **OR** correct structure 	**1**	
(ii)	0.9-1.0 is (2 x)$CH_3R/CH_3/RCH$ multiplet/1.8 is CHR/R_3CH singlet/2.5 is OH 3.4 is CH_2O/CH_3O	**1** **1** **1** **1**	
(iii)	doublet 1H/one proton on adjacent carbon	**1** **1**	

(iv)	OH peak or one peak disappears OH proton is labile ***or*** exchanges for D of D_2O ***or*** as an equation e.g. D_2O + OH → DOH + OD as a minimum	**1** **1**	**[9]**
Total			**12**
			100