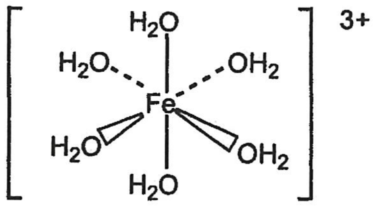
Question			Expected answers	Marks	Additional guidance
2	(a)		Octahedral shape with some indication of three dimensions (1); Bond angle 90° (1) 	2	**Allow** use of wedges and dotted lines to indicate three dimensions **Allow** three dimensions if at least two bond angles of 90° are shown that clearly demonstrate 3D **If two different bond angles** do not award bond angle mark
	(b)		Lone pair on oxygen / electron pair on oxygen (1); Donated to the (central) metal (ion) (1) **Or** A dative bond exists between water and the central metal (ion) (1) and if electron pair comes from oxygen (1)	2	**Allow** water is an electron pair donor **Allow** metal (ion) is an electron pair acceptor **Allow** marks from a diagram
	(c)	(i)	All Points plotted correctly (1); Two straight lines of best fit that intersect (1)	2	**Allow** to nearest half small square
		(ii)	13.0 – 13.6 (1)	1	**Unit not needed** **Allow** ecf from incorrect graph
		(iii)	Answer to part (ii) × 10^{-3} × 0.0500 (1)	1	**Allow** ecf
		(iv)	20 – Answer to part (ii)	1	
		(v)	Answer to part (iv) × 10^{-3} × 0.100 (1)	1	**Allow** ecf
		(vi)	x = 1 and y = 5 (1)	1	**Allow** ecf of x and y that add up to 6
	(d)	(i)	Moles of K = 0.014, Fe = 0.0035, C = 0.021 and N = 0.021 / molar ratio is K:Fe:C:N is 14:3.5:21:21 (1); $K_4Fe(CN)_6$ / $K_4FeC_6N_6$ (1)	2	**Ignore** order of atoms in the formula
		(ii)	$[Fe(CN)_6]^{4-}$ (1)	1	**Allow** $Fe(CN)_6^{4-}$ / $FeC_6N_6^{4-}$
				Total = 14	

Question			Expected answers	Marks	Additional guidance
3	(a)		Silver (1)	1	
	(b)		0.0071 (g) (1)	1	
	(c)	(i)	Ag + $CuCl_2$ → AgCl + CuCl (1)	1	
		(ii)	Oxidation because oxidation state of silver changes from 0 to +1 (1); Reduction because oxidation state of copper changes from +2 to +1 (1)	2	**Allow** ecf from wrong equation
	(d)	(i)	$(1s^2 2s^2 2p^6) 3s^2 3p^6 3d^9$ (1)	1	
		(ii)	Copper(II) ions have an incomplete set of 3d electrons / partially filled d (sub) shell / partially filled d orbital (1)	1	
				Total = 7	

Question	Expected answers	Marks	Additional guidance
4		12	**Definition** maximum of marks **Factors** maximum of marks **Decomposit** maximum of marks – marl can either co from the polarisation explanation o lattice enthalı explanation b **not both**
	Definition – maximum of two marks The enthalpy change that accompanies the formation of one mole of a solid (compound) (1); from its constituent gaseous ions (1)		**Allow** marks an equation **Allow** energy released / en change **Not** energy required **Allow** ionic compound / s
	Factors – maximum of four marks As ionic charge increases it becomes more exothermic / ora(1); Since there will be a stronger (electrostatic) attraction between the (positive and negative) ions / ora (1); As ionic radius decreases becomes more exothermic / ora (1); Since the ions become closer together / ora (1); so the (positive and negative) ions are more strongly attracted to one another / aw (1)		**Allow** lattice enthalpy becc larger if it is cl from the defin that lattice enthalpy is exothermic / c

Question	Expected Answers	Marks
1(a)	From orange to green (accept green/blue but not blue)	2
(b) (i)	Diagram to show	
	Salt bridge	1
	Voltmeter	1
	Solution containing both $Cr_2O_7^{2-}$ and Cr^{3+}	1
	Platinum electrode	1
(ii)	Pressure 101 kPa/1 Atm/100kPa	1
	Temperature 298K/25^0 C	1
	Concentration of each solution 1 mol.dm^{-3}	1
(c)	$3H_2 + Cr_2O_7^{2-} + 8H^+ \rightarrow 2Cr^{3+} + 7H_2O$	
	Correct species both sides	1
	Balancing (do not allow if electrons or H^+ not cancelled)	1
(d)	Equilibrium involving $Cr_2O_7^{2-}$ moves to RHS	1
	Therefore SEP more positive or $Cr_2O_7^{2-}$ gains electrons more readily / is more easily reduced / becomes a better oxidising agent	1
		Total:13

Question	Expected Answers	Marks
3 (a)	Formula / Co-ordination number / O.S.	
	$[Ni(H_2O)_6]^{2+}$ 6 +2	2
	$CuCl_2^-$ 2 +1	2
(b)	Both types of isomerism involve fixed geometry/have different arrangement in space/both are stereoisomers Cis – trans: Suitable ligands with correct formulae 2 diagrams correctly labelled cis and trans Optical: Non-superimposable mirror images Rotate (plane) polarised light Need for correct formula bidentate ligand / 4 different ligands arranged tetrahedrally / any other asymmetric complex 2 diagrams correct charges on all formulae	1 1 2 1 1 1 1 2 1
	QWC The response must be well organised and logical. It must contain a minimum of 3 technical terms from the following list: Stereoisomerism, non-superimposable, mirror images, bidentate, ligand, plane polarised, asymmetric, chiral, enantiomers, octahedral, square planar, tetrahedral.	Max 9 for (b) 1
		Total: 14

Question	Expected Answers	Marks
4 (a)	A redox reaction involves oxidation and reduction Choses: $2Cu^{+} \rightarrow Cu^{2+} + Cu$ Identify species oxidised and reduced by use of oxidation numbers or electron transfer	1 1 1
(b)	Chooses: $CoCl_4^{2-} + 6NH_3 \rightarrow [Co(NH_3)_6]^{2-} + 4Cl^-$ Replacement of existing ligand By a stronger ligand / a different ligand present in higher concentration Allow stepwise replacement of one ligand by another for 2 marks	 1 1 1 Total: 6

Question			Expected Answers	Marks
1	(a)	(i)	rate at start (of reaction)/ t=0 ✓	[1]
		(ii)	0.048 (mol dm^{-3} s^{-1}) ✓	[1]
	(b)	(i)	$C_{12}H_{22}O_{11}$(aq): Exp 2 has twice [$C_{12}H_{22}O_{11}$ (aq)] as Exp 1 and rate x 2 ✓, so order = 1 with respect to $C_{12}H_{22}O_{11}$ ✓ HCl(aq): Exp 3 has 1.5 x [HCl] as Exp 1 and rate increases by 1.5 ✓, so order = 1 with respect to HCl(aq) ✓ *ORDER HAS TO BE CORRECT TO GET REASON MARK*	[4]
		(ii)	2/second order ✓ This will be dependent on answer to (i)	[1]
		(iii)	rate = k[$C_{12}H_{22}O_{11}$] [HCl] ✓✓ OR rate = 2.4 [$C_{12}H_{22}O_{11}$] [HCl] ✓✓ *rate* = k [$C_{12}H_{22}O_{11}$] [H_2O] scores 1 mark) *rate* = [$C_{12}H_{22}O_{11}$] [HCl] scores 1 mark) k [$C_{12}H_{22}O_{11}$] [HCl] scores 1 mark) k = [$C_{12}H_{22}O_{11}$] [HCl] scores zero Check for ecf from (i)	[2]
	(c)		increases ✓	[1]
	(d)	(i)	time for concentration (of a reactant) to fall to half the original value ✓	[1]
		(ii)	$C_{12}H_{22}O_{11}$: 0.05 mol dm^{-3} ✓ In one half life, [$C_{12}H_{22}O_{11}$], concentration halves 0.1/2 ✓ HCl: 0.1 mol dm^{-3} ✓ *Assume* mol dm^{-3} unless told otherwise *Assume* 'mol dm^3 means mol dm^{-3} but Penalise wrong unit once only	[3]
				Total: 14

Question	Expected Answers	Marks
2 (a) (i)	$K_c = \frac{[NO]^2}{[N_2][O_2]}$ ✓✓ *award 1 mark if upside down* *K_p expression worth 1 mark*	[2]
(ii)	Equil ⟶ left because K_c is very small	[1]
(iii)	$[O_2(g)] = \frac{[NO]^2}{[N_2] \times K_c} = \frac{(4.0 \times 10^{-16})^2}{1.1 \times 4.8 \times 10^{-31}}$ ✓ = 0.30 mol dm^{-3} ✓ (calculator: 0.303030303) answer given to 2 sig figs ✓ 3.3 ✓✓ (upside down) calc: 3.3 7.6×10^{14} ✓✓ (missing out ^{2}) calc: 7.5757..... 0.37 ✓✓ (1.1 on top) calc: 0.366666.. 5.2×10^{-46} ✓✓ ('4' values swapped) calc: $5.236363. \times 10^{-46}$	[3]
(b) (i) (ii)	ΔH is +ve ✓ equilibrium moves to the right to compensate for increase in temperature/to lower the temperature / to minimise the change ✓ increase in proportion of NO ✓ because K_c increases *Can be linked to either increased proportion of NO or enthalpy change* ✓	[4]
(iii)	$2NO + O_2 \longrightarrow 2NO_2$ ✓✓ *species correct for 1st mark* *'simplest' balanced equation for 2nd mark* $NO + {}^1/_2O_2 \longrightarrow NO_2$ also gets both marks *N_2O_4 is fine* *NO_2 for 1st mark*	[2]

(c)	Optimum Pressure low pressure ✓ fewer gaseous moles on left ✓ Optimum Temperature optimum: low temperature ✓ forward reaction is exothermic ✓ Reason mark can only be awarded if the condition mark is correct. Condition mark is independent 1000°C used to increase rate with more energetic collisions *OR* so that a greater proportion of molecules exceed activation energy ✓ 10 atm used to increase rate by increasing concentration *OR* increasing collisons ✓ Catalyst used to increase rate by lowering the activation energy/providing a lower energy route ✓ *NOT increase equilibrium yield* Quality of written communication: Recognition of a compromise between rate and equilibrium amount ✓	[7] [1]
		Total: 20

Question			Expected Answers	Marks
3	(a)	(i)	pH = –log[H^+(aq)] ✓ *state symbols not needed*	[1]
		(ii)	HBr is stronger than CH_3COOH because pH is lower ✓ HBr dissociates more/more H^+ ions……. for the same concentration ✓	[2]
		(iii)	diluting by a factor of 10/ 10-fold dilution ✓ pH = 3 ✓ Credit a calculated pH for ecf from a wrong dilution with working shown	[2]
	(b)	(i)	K_w = [H^+(aq)] [OH^-(aq)] ✓ *state symbols not needed*	[1]
		(ii)	$[H^+(aq)] = \frac{K_w}{[OH^-(aq)]} = \frac{1.0 \times 10^{-14}}{0.0200} = 5 \times 10^{-13} mol\ dm^{-3}$ ✓ pH = –log (5 x 10^{-13}) = 12.30 ✓ (accept calc value: 12.30103) ecf is possible for pH mark providing that the [H^+] value has been derived from K_w/[OH^-] If pOH method is used, pOH = 1.7 would get 1st mark, pH = 14 – 1.7 = 12.3 gets 2nd mark.	[2]
	(c)	(i)	start at pH=3.4 (approx half way up 0-7 rise) ✓ sharp rise at 20 cm^3 (must have a vertical part) ✓ finish higher above pH 7 than starting pH ………………with line continued to 50 cm^3 ………………but finish pH is less than 14 ✓ NOTE that lines should not loop	[3]
		(ii)	Indicator that has a pH range coinciding with steepest part of titration curve in (i). Likely to be thymol blue OR brilliant yellow✓ pH range coincides with ……pH change during sharp rise /equivalence point ✓	[2]
				Total: 13

Question			Expected Answers	Marks
4	(a)		P : O = 43.7/31 : 56.3/16 / 1.41 : 3.52 ✓ Ratio P:O = 2 : 5 / Empirical formula = P_2O_5 ✓ Molecular formula = P_4O_{10} (from M_r value) ✓	[3]
			$Ca_3(PO_4)_2$ ✓	[1]
			Equations: $P_4 + 5O_2 \longrightarrow P_4O_{10}$ ✓ (or $P_4 + 5O_2 \longrightarrow 2P_2O_5$) $P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$ ✓ (or $P_2O_5 + 3H_2O \longrightarrow 2H_3PO_4$) $Ca_3(PO_4)_2 + 3H_2SO_4 \longrightarrow 2H_3PO_4 + 3CaSO_4$ ✓ A candidate who writes an equation forming P_4O_6 or P_2O_3 can score the equation mark for oxidation of P_4.	[3]
4	(b)	(i)	$H_3PO_4 > H_2PO_4^{-} > HPO_4^{2-}$ Increased strengths with increasing K_a values✓	[1]
		(ii)	Molar mass of Na_2HPO_4 = 142 g mol^{-1} ✓ amount of Na_2HPO_4 = 4.26/142 = 0.03 mol ✓ *e.c.f. mass/molar mass* volume of H_3PO_4 needed = 0.03 x 1000 / 0.5 = 60 cm^3 ✓ *e.c.f. moles Na_2HPO_4 x 1000/0.5* amount of NaOH = 2 x 0.03 = 0.06 mol ✓ *e.c.f. 2 x moles Na_2HPO_4* volume of NaOH needed = 0.06 x 1000 / 0.5 = 120 cm^3 ✓ *e.c.f. moles NaOH x 1000/0.5* Penalise units once.	[5]
				Total: 13