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Abbreviations, annotations and conventions used in the Mark Scheme

/ = alternative and acceptable answers for the same marking point
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ecf = error carried forward
AW = alternative wording
ora = or reverse argument

Question	Expected answers	Marks	Additional guidance
2 (a) (i)	$CaCO_3 \rightarrow CaO + CO_2$ (1)	1	**Ignore** state symbols
(ii)	Calcium ion has a larger charge density than barium ion / Ca^{2+} has a smaller ionic radius than Ba^{2+} / ora (1); So calcium ion polarises the carbonate (ion) **more** than the barium ion / so Ca^{2+} distorts the CO_3^{2-} **more** than Ba^{2+} / ora (1)	2	Particles referred to must be correct **Not** Ca has a higher charge density **Not** calcium has a higher charge density **Allow** calcium has a smaller ionic radius **Allow** correct description of **more** polarisation **Allow** CO_3^- **Not** Ca^{2+} polarises CO_3
(b) (i)	Oxidation state of nitrogen goes from +5 to +4 (1); Oxidation state of oxygen goes from -2 to 0 (1); Correct linking of changes of oxidation state with reduction **and** with oxidation (1)	3	If oxidation state of barium given is incorrect **max 1** for the oxidation numbers. **Allow** ecf from wrong oxidation states for the correct linking mark **Both** oxidation **and** reduction needed
(ii)	Correct use of molar ratios (1); Correct cycle (1); (+)1000 (kJ mol^{-1}) (1)	3	**Award** full marks for (+) 1000 (kJ mol^{-1}) **Only allow** ecf for final lattice energy answer from a correct cycle **Allow** -1000 (1), + 467 (2), +901 (2), +1558 (2),

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Question	Expected answers	Marks	Additional guidance
2 (c) (i)	Moles of $Ba(NO_3)_2$ = 0.005 or 0.00502 (1); Moles of gas made = 0.0125 / 0.0126 (1); Volume of gas = 300 cm^3 to 302 cm^3 (1)	3	**Allow** ecf within question **Ignore** significant figures
(ii)	Decomposition temperature may be too high / too much gas will be produced / to fill a gas syringe need a smaller amount of solid / gas syringe too small (1)	1	**Allow** NO_2 is toxic / barium compounds are toxic Answer is **consequential** on answer to (i)
(d) (i)	Enthalpy change when one mole of a solid / energy released when one mole of solid (1); Is made from its gaseous ions (1)	2	**Not** energy required **Allow** marks via an equation **Allow** ionic compound / crystals instead of solid
(ii)	Calcium (ion) has a higher charge density / smaller (ionic) radius / ora (1); So it is **more** strongly attracted to the oxide (ion) / ora (1)	2	**Allow** calcium oxide has stronger ionic bond / ora
		Total = 17	

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Question	Expected answers	Marks	Additional guidance
3	**Transition element** Cu^{2+} $1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$ (1); Transition elements have one oxidation state that has an incomplete set of 3d electrons / have one ion with a half-filled 3d orbital (1) **Complex ion** Example of a **copper** complex ion e.g. $[Cu(H_2O)_6]^{2+}$ or $CuCl_4^{2-}$ (1); Diagram of the copper complex showing three dimensions e.g. use of wedges or dotted lines (1); Correct bond angle to match the complex / correct name of the shape of the complex (1); Ligand is an electron **pair** donor (1); Copper(II) ion is an electron **pair** acceptor (1); Dative bond exists between ligand and the copper(II) ion (1) **Properties** Several oxidation states e.g. copper has +1 and +2 or iron has +2 and +3 (1); Forms coloured compounds e.g. copper(II) chloride is green or iron(II) sulphate is pale green (1); Element or compound has catalytic properties e.g. Iron is a catalyst in the Haber process (1)	11	**Allow** has at least one half-filled d orbital / partially filled 3d sub-shell If a copper complex that does not exist is used then first three marks not available If a correct iron complex is given then example mark cannot be awarded **Allow** square planar where appropriate Electron pair donor, electron pair acceptor and dative bond marks can awarded from an appropriate diagram Ignore copper has a +3 Ignore iron has a +6 oxidation state

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Question	Expected answers	Marks	Additional guidance
3	**Quality of written communication** Use of technical terms – at least three terms from the following list are used in the correct context • ligand • dative bond • coordinate bond • tetrahedral • square planar • octahedral • oxidation (state) • catalyst • electron pair • lone pair • orbital • sub-shell (1)	1	Put a ring around the technical terms
		Total = 12	

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Question	Expected Answers	Marks
1 (a)	Emf of a cell / voltage / potential difference / cell potential	1
	Comprising half cell combined with standard hydrogen electrode	1
	Conc = 1 mol.dm^{-3}; Pressure (of H_2) = 1 atm; Temp = 298K (all of above=1mark)	1
(b)	+0.16 V (unit required)	1
(c) (i)	$2MnO_4^- + 10Cl^- + 16H^+ \rightarrow 2Mn^{2+} + 5Cl_2 + 8H_2O$	
	correct species on both sides of equation	1
	equation balanced	1
	(ignore electrons for first mark, penalise for balance)	
(ii)	Chlorine -1 → 0	1
	Manganese +7 → +2	1
	Link to c(i) and allow ecf	
(iii)	Chloride ion oxidised (not chlorine)	1
	Manganate(VII) ion reduced (not manganese)	1
(d)	0.16 V too small/rate too slow/insufficient activation energy/not standard conditions	1
(e)	Peak between 500-550 nm	1
		Total: 12

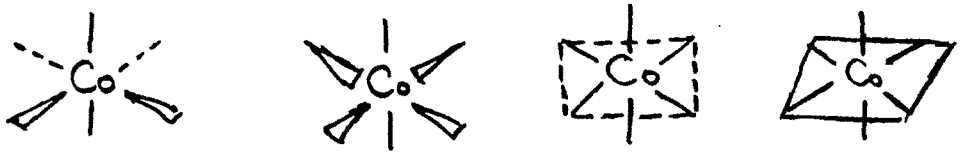
Question	Expected Answers	Marks
2 (a) (i)	Zinc	1
(ii)	Coins + resist corrosion (not rusting) / hard wearing Or statues + resist corrosion/ attractive patina Or electrical connections + good conductor Or musical instruments + attractive / sonorous Or plumbing fixtures + hard / corrosion resistant	1
(b) (i)	Sodium carbonate/sodium hydroxide/other suitable named alkali (accept correct formulae) Do not accept 'alkali' on its own	1
(ii)	Starch	1
(iii)	Just before the end point/when solution turns pale straw	1
(c) (i)	0.002 mol	1
(ii)	One (1)	1
(iii)	0.002 mol	1
(iv)	0.002 mols Cu^{2+} contains 0.002 x 63.5 g of Cu =0.127 g 250 cm^3 of solution contains10 x 0.127 g = 1.27 g % Cu = 1.27/1.65 x 100 = 77.0% (Allow 76.9-77.0; allow ecf)	1 1 1 **Total: 11**

Question	Expected Answers	Marks
3 (a)	Number of coordinate / dative covalent bonds attached to metal ion / number of lone pairs accepted (not number of ligands)	1
(b) (i)	$[Co(H_2O)_6]^{2+}$ is octahedral; $[CoCl_4]^{2-}$ is tetrahedral Drawings must be 3 dimensional (See additional sheet for acceptable 3-d diagrams)	2
(ii)	Pink → blue	2
(iii)	Add water. (Allow other suitable suggestions, e.g. add lead nitrate to precipitate Cl^- as $PbCl_2$)	1
(c)	$[Co(NH_3)_6]^{2+}$ $E^{\ominus}$ for forward reaction is least positive Reverse reaction (oxidation) more likely to occur	1 1 1
(d)	Ammonia is a stronger ligand than water / ammonia forms stronger bonds / ammonia is a stronger base / ammonia can donate its lone pair more easily	1
		Total: 10

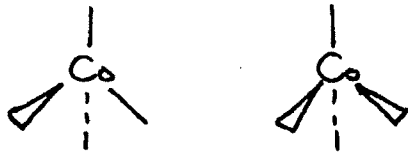
2815/06 Transition Elements June 2005 - Additional Sheet.

Question 3

(b) (i) Acceptable shapes for $[Co(H_2O)_6]^{2+}$ include:

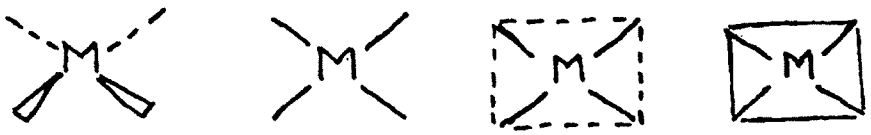


Acceptable shapes for $[CoCl_4]^{2-}$ include:



Question 4

(b) Any examples which show the principle of cis/trans isomerism and optical isomerism are fine but, all diagrams must be 3-d. The shapes, shown in Q3 are allowed for octahedral or tetrahedral. For square planar complexes used to illustrate cis/trans isomerism the following illustrations are fine. For optical isomerism, there must be a mirror line and the isomers must be non-superimposable object/mirror images.



Question	Expected Answers	Marks
4 (a) (i)	Cis platin	1
(ii)	Binds to DNA	1
	Prevents cell from replicating / cells die	1
(b)	(Cis/trans) + Examples (must be 3-d drawings)	2
	Correctly labelled as cis and trans (allow this mark if diagrams are planar)	1
	Cis has same atoms at 90^0 + Trans has same atoms at 180^0 (need reference to bond angles for mark)	1
	(Optical) + examples (must be 3-d drawings)	2
	Rotate plane polarised light (by same number of degrees) in opposite directions	1
	Non-superimposable mirror images	1
	NB If use $H_3N\ CH_2\ CH_2\ NH_3$ penalise only once	
	(see additional sheet for acceptable 3-d diagrams)	
	QWC – to be awarded for the correct use of scientific terms, to include at least 3 of the following: Cis & trans, optical, plane, polarised, non-superimposable, mirror images, geometric, bidentate, ligand, octahedral, square planar, tetrahedral	1
		Total: 12

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Question			Expected Answers	Marks
1	(a)	(i)	constant half-life ✓	[1]
		(ii)	rate = k $[N_2O_5]$ ✓ Common error will be to use '2' from equation.	[1]
		(iii)	curve downwards getting less steep ✓ curve goes through 1200,0.30; 2400,0.15; 3600,0.075 ✓	[2]
		(iv)	tangent shown on graph at t = 1200 s ✓	[1]
		(v)	3.7(2) x 10^{-4} ✓ mol dm^{-3} s^{-1} ✓ ecf possible from (ii) using $[N_2O_5]^x$ (2nd order answer: 2.2(3) x 10^{-4})	[2]
	(b)	(i)	slow step ✓	[1]
		(ii)	$(CH_3)_2C{=}CH_2 + H_2O \longrightarrow (CH_3)_3COH$ ✓	[1]
		(iii)	H^+ is a catalyst ✓ H^+ used in first step **and** formed in second step/ regenerated/ not used up ✓	[2]
		(iv)	rate = k $[(CH_3)_2C{=}CH_2]$ $[H^+]$ ✓ common error will be use of H_2O instead of H^+	[1]
				Total: 12

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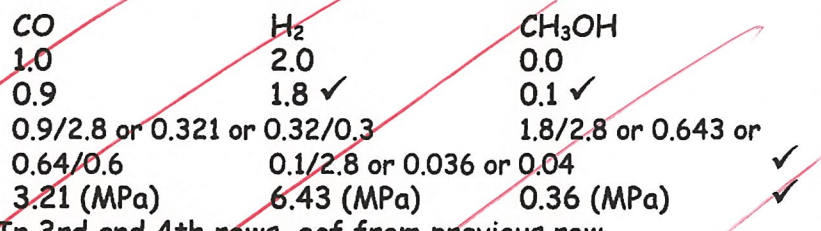
Question	**Expected Answers**	**Marks**
2 (a)	**High Pressure** Equilibrium ⟶ right as fewer moles on right hand side and the shift reduces number of molecules/compensates for increasing pressure ✓ Rate increases/ more collisions ✓	[2]
	High temperature Equilibrium ⟶ left as equilibrium goes to the left to compensate for increased temperature/absorbs the energy/in endothermic direction (ora) ✓ Rate increases/ more successful collisions ✓	[2]
	Other effect High pressures expensive/ high temperatures expensive /high pressures cause safety problems ✓	[1]
QoWC:	One correct statement followed by correct explanation ✓	[1]
(b) (i)	 CO H_2 CH_3OH 1.0 2.0 0.0 0.9 1.8 ✓ 0.1 ✓ 0.9/2.8 or 0.321 or 0.32/0.3 1.8/2.8 or 0.643 or 0.64/0.6 0.1/2.8 or 0.036 or 0.04 ✓ 3.21 (MPa) 6.43 (MPa) 0.36 (MPa) ✓ In 3rd and 4th rows, ecf from previous row	[4]
(ii)	$K_p = \dfrac{p(CH_3OH)}{p(CO) \times p(H_2)^2}$ ✓✓ 1 mark for K_c/ use of any [ ] /inverted/power missing.	[2]
(iii)	K_p stays the same ✓ Equilibrium position moves to the right/yield increases ✓ in response to increase in reactants ✓	[3]
(iv)	$K_p = \dfrac{0.261}{3.70 \times 5.10^2} = 2.71 \times 10^{-3}$ ✓ MPa^{-2} ✓ calc value 2.7120546×10^{-3}; answer and/or units ecf from (ii)	[2]
(c)	$CH_3OH + 1.5O_2 \longrightarrow CO_2 + 2H_2O$ ✓	[1]
		Total: 18

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Question	**Expected Answers**	**Marks**
3 (a) (i)	completely dissociates/ionised ✓ proton donor ✓	[2]
(ii)	NO_3^- ✓	[1]
(b) (i)	pH = –log[H^+] / –log(0.015) ✓ = 1.82 / 1.8 ✓ (Not 2)	[2]
(ii)	[H^+] = 0.0075 mol dm^{-3} pH = –log(0.0075) = 2.12 / 2.1 ✓	[1]
(c) (i)	K_w = [H^+(aq)] [OH^-(aq)] ✓ *state symbols not needed*	[1]
(ii)	[H^+(aq)] = 10^{-pH} = $10^{-13.54}$ = 2.88/2.9 x 10^{-14} mol dm^{-3} ✓ [NaOH] / [OH^-(aq)] = $\frac{K_w}{[H^+(aq)]} = \frac{1.0 \times 10^{-14}}{2.88 \times 10^{-14}}$ = 0.347 / 0.35 mol dm^{-3} ✓	[2]
(d) (i)	a solution that minimises/resists/opposes pH changes ✓	[1]
(ii)	The buffer must contain both CH_3COOH and CH_3COONa / CH_3COO^- /weak acid and conjugate base ✓ Solution **A** is a mixture of CH_3COOH and CH_3COONa / / has an excess of acid /is acidic ✓ Solution **B**, contains only CH_3COONa/ only CH_3COO^- /only the salt/ is neutral ✓ $CH_3COOH(aq) + NaOH(aq) \longrightarrow CH_3COONa(aq) + H_2O(l)$ / acid/alkali has been neutralised/ $CH_3COOH(aq)$ and NaOH react together ✓	[4]
(e)	[H^+] increases ✓ H_2O ionises more / for $H_2O \rightleftharpoons H^+ + OH^-$, equilibrium moves to the right ✓ exo/endo is 'noise'	[2]
		Total: 15

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Question	**Expected Answers**	**Marks**
4 (a)	moles of Cu = 0.68 x 5/1000 = 0.0034 ✓ mass of Cu = 0.0034 x 63.5 = 0.216 g ✓ % Cu = 0.216/0.28 = 77% ✓	[3]
	ratios: Cu = 26.29/63.5 = 0.41 1 N= 11.6/14 = 0.83 OR 2 O = 59.63/16 = 3.73 9 H= 2.48/1 = 2.48 6 ✓ empirical formula = $CuN_2O_9H_6$ ✓ Formula with $3H_2O$ shown separately scores 1: i.e. $CuN_2O_6.3H_2O$ ✓ Correct formula shown with $(NO_3)_2$ scores 2nd mark: $Cu(NO_3)_2.3H_2O$ ✓ (Correct answer automatically scores both marks)	[2] [2]
(b)	Cu ⟶ Cu^{2+}: Cu from 0 to +2 ✓ NO_3^- ⟶ NO: N from +5 to +2 ✓ $3Cu + 8H^+ + 2NO_3^- \longrightarrow 3Cu^{2+} + 2NO + 4H_2O$ ✓ 'simple balance' as the only creditworthy response scores 1 mark: i.e. $Cu + 4H^+ + NO_3^- \longrightarrow Cu^{2+} + NO + 2H_2O$	[3]
(c)	moles of A = 90/24000 = 3.75×10^{-3} ✓ M_r of A = 0.24/ 3.75×10^{-3} = 64 ✓ Gas is SO_2 ✓ $Cu + 2H_2SO_4 \longrightarrow CuSO_4 + SO_2 + 2H_2O$ / $Cu + 4H^+ + SO_4^{2-} \longrightarrow Cu^{2+} + SO_2 + 2H_2O$ / $Cu + 3H^+ + HSO_4^- \longrightarrow Cu^{2+} + SO_2 + 2H_2O$ ✓	[4]
		Total: 14