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MARK SCHEME

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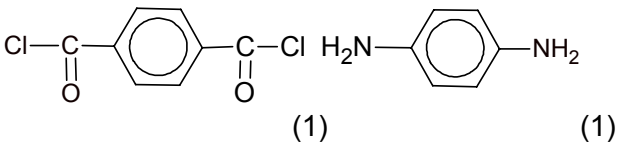
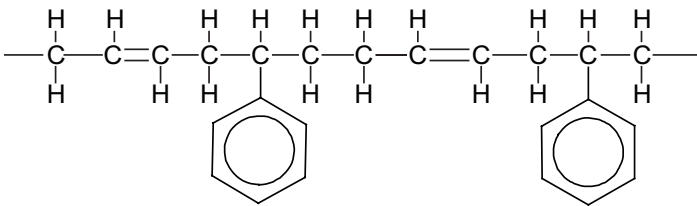
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This document consists of **10** printed pages.

Question	Answer	Marks
1(a)(i)	Minimum of two correct half-life calculations, ca. 1100 s (1) Constant half-life so first order (1)	2
1(a)(ii)	Rate = $k[\text{N}_2\text{O}_5]$	1
1(a)(iii)	Values from graph used in $\ln(C_0/C_t) = kt$ e.g. $\ln(2.35/0.5) = k \times 2500$ (1) Rearrange for k e.g. $k = \{\ln(2.35/0.5)\}/2500 = 1.548/2500$ (1) Correct answer with units = $6.190 \times 10^{-4} \text{ s}^{-1}$ (1)	3
1(a)(iv)	Slowest step (in the mechanism)	1
1(a)(v)	Adds up all 3 steps and show that they cancel to the overall equation	1
1(b)(i)	1st order	1
1(b)(ii)	2nd order	1
1(b)(iii)	Working using any other set of data. e.g. using experiment 3 = $9.22 \times 10^{-7} \times (5/3)^2$ (1) = $2.561 \times 10^{-6} \text{ (mol dm}^{-3} \text{ s}^{-1})$ (1)	2
1(b)(iv)	Rate = $k[\text{H}_2][\text{NO}]^2$	1
1(b)(v)	$k = \text{rate}/([\text{H}_2][\text{NO}]^2)$ e.g. using experiment 3 = $9.22 \times 10^{-7}/(0.1 \times 0.3^2)$ 1.024×10^{-4} (1) $\text{dm}^6 \text{ mol}^{-2} \text{ s}^{-1}$ (1)	2

Question	Answer	Marks
2(a)(i)	Proton / H ⁺ donor	1
2(a)(ii)	$\text{HF} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{F}^- \quad (1)$ <p style="text-align: center;">acid1 base2 acid2 base1 (1)</p>	2
2(b)(i)	<p>50 cm³ 0.002 mol dm⁻³ HCl in total volume of 100 cm³ = 0.001 mol dm⁻³ (1)</p> <p>pH = -log₁₀[H⁺] so [H⁺] = 10^{-pH} = 10⁻³ = 0.001 mol dm⁻³ (1)</p> <p>i.e. HCl fully dissociated so strong (1)</p>	3
2(b)(ii)	$(K_a =) \frac{[\text{H}_3\text{O}^+][\text{F}^-]}{[\text{HF}]}$	1
2(b)(iii)	<p>[HF] = [F⁻] so pH = pK_a (1)</p> <p>so K_a = [H⁺] = 10^{-3.2} = 6.31 × 10⁻⁴ mol dm⁻³ (1)</p> <p>H⁺ reacts with F⁻ / the HF ⇌ H⁺ + F⁻ equilibrium shifts left (1)</p> <p>(so) approx. constant [H⁺] (1)</p>	4
2(b)(iv)	<p>6.31 × 10⁻⁴ = [H⁺]²/0.1</p> <p>[H⁺] = √(6.31 × 10⁻⁴ × 0.1) = 7.944 × 10⁻³ (1)</p> <p>pH = -log[H⁺] = -log 7.944 × 10⁻³ = 2.10 (1)</p>	2
2(b)(v)	<p>H–F stronger bond than H–Cl AND HF is a weaker acid than HCl (1)</p> <p>so H–F dissociates less (1)</p>	2

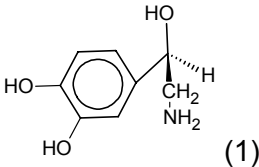
Question	Answer	Marks
2(c)(i)	pH at start = 2.1 (1) Steep up then levelling off (1) pH and volume at half equivalence (3.2 and 15 cm ³) (1) Equivalence point at 30 cm ³ and vertical for at least one square (1) Levelling off at pH 11–13 (1)	5
2(c)(ii)	Phenol red (1) pK _a corresponds to pH at equivalence point (1)	2

Question	Answer	Marks
3(a)(i)	A = condensation (1) B = addition (1) C = condensation (1)	3
3(a)(ii)	A = amide (1) C = glycosidic (1)	2
3(a)(iii)	 (1) (1)	2
3(a)(iv)	 2 benzene rings only attached to the main carbon chain (1) Rest correct (1)	2

Question	Answer	Marks
3(b)(i)	No change in functional group level (1) Hydrolysis (1) $\text{H}^+(\text{aq})$ / aqueous acid (1) FGL of COO carbon falls / changes from carboxylic to alcohol level / from 3 to 1 (1) Reduction (1) LiAlH_4 (1)	6
3(b)(ii)	Acidified dichromate / H^+ with $\text{Cr}_2\text{O}_7^{2-}$	1
3(b)(iii)	$\text{C}_2\text{H}_5\text{OH} + 2[\text{O}] \rightarrow \text{CH}_3\text{CO}_2\text{H} + \text{H}_2\text{O}$ Correct species (1) Balancing (1)	2
3(b)(iv)	Reaction 3: Reflux (1) Reaction 4: (Immediate / continuous) distillation (1) Reflux ensures aldehyde intermediate remains in reaction mixture or distillation removes aldehyde to avoid further oxidation (1)	3

Question	Answer	Marks
4(a)(i)	Increasing anion size F to I / down the group (1) Cu ²⁺ is smaller than Cu ⁺ (1) Greater charge of Cu ²⁺ than Cu ⁺ (1) (so) increased attraction linked to more exothermic lattice energies (1)	4
4(a)(ii)	Calculation of predicted value based on ionic model assumes perfect ionic character / spherical ions (1) Bromide more polarisable than fluoride (1) Partial covalency greater in bromide (1)	3
4(b)(i)	$E^{\circ} = +0.51 \text{ V}$ Sign (conditional on answer) (1) Value (1)	2
4(b)(ii)	Blue (solution) (of Cu ²⁺) (1) Brown solid (of copper metal) (1)	2
4(b)(iii)	$E^{\circ}_{\text{cell}} (298 \text{ K}) = 0.87 - 0.54 = +0.33 \text{ V}$ (1) $\Delta G = -nFE^{\circ}_{\text{cell}} = -1 \times 9.65 \times 10^4 \times 0.33 = -31845$ (1) $-31845 = -(8.31)(298) \ln K_c$; $K_c = 3.84 \times 10^5$ (1)	3
4(b)(iv)	White solid (of CuI) OR brown solution (of I ₂)	1

Question	Answer	Marks
4(c)	<p>W = CuO (1)</p> <p>X = Cu₂O (1)</p> <p>Y = Cu(H₂O)₆²⁺ (1)</p> <p>Z = CuCl₄²⁻ (1)</p> <p>CuCO₃ → CuO + CO₂ (1)</p> <p>4CuO → 2Cu₂O + O₂ (1)</p> <p>CuO + H₂SO₄ + 5H₂O → Cu(H₂O)₆²⁺ + SO₄²⁻ (1)</p> <p>2Cu²⁺ + 4I⁻ → 2CuI + I₂ (1)</p> <p>Cu(H₂O)₆²⁺ + 4Cl⁻ → CuCl₄²⁻ + 6H₂O (1)</p> <p>Y = octahedral AND Z = tetrahedral (1)</p>	10

Question	Answer	Marks
5(a)(i)	rotates (plane) polarised light anticlockwise	1
5(a)(ii)	 <p>Assigns correct priority order OH = 1; CH₂NH₂ = 2; ring = 3; H = 4 (1) With lowest priority group facing away / into page remaining groups rank in decreasing order in clockwise direction (1)</p>	3
5(b)(i)	(Nucleus has) spin	1
5(b)(ii)	<p>Electrons create shielding (1) More shielding = signal shifts upfield / lower values (of delta) / to the right (1)</p>	2

Question	Answer	Marks
5(c)	<div data-bbox="344 215 640 335"> </div> <p data-bbox="344 371 987 438">Fits molecular formula and tri-substituted ring (1) Rest correct (1)</p> <div data-bbox="344 438 1050 585"> </div> <p data-bbox="344 624 913 691">Phenol OH reacts to form correct ester (1) Alcohol OHs react to form correct esters (1)</p> <div data-bbox="344 758 1034 863"> </div> <p data-bbox="344 900 987 933">Signals A to C singlets due to 3 O–H protons (1)</p> <p data-bbox="344 967 1048 1000">Signal D due to CH proton in CHOHCH₂OH group (1)</p> <p data-bbox="344 1034 1072 1067">Signal E due to CH₂ protons in CHOHCH₂OH group (1)</p> <p data-bbox="344 1101 949 1134">Signal F due to CH₃ protons on CH₃ group (1)</p> <p data-bbox="344 1168 1120 1235">Signal D is a triplet because split by 2 neighbouring protons AND</p> <p data-bbox="344 1235 1160 1302">Signal E is a doublet because split by one neighbouring proton AND</p> <p data-bbox="344 1302 1223 1335">Signal F is a singlet because there are no neighbouring protons (1)</p>	10