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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)	$3.7(2) \times 10^{-4}$ ✓ mol dm^{-3} s^{-1} ✓ ecf possible from (ii) using $[N_2O_5]^x$ (2nd order answer: $2.2(3) \times 10^{-4}$)	[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)	$K_p = \frac{p(CH_3OH)}{p(CO) \times p(H_2)^2}$ ✓✓ 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)	$K_p = \frac{0.261}{3.70 \times 5.10^2} = 2.71 \times 10^{-3}$ ✓ 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 = $CuN_2O_9H_6$ ✓	[2]
	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]
(b)	$Cu \longrightarrow Cu^{2+}$: Cu from 0 to +2 ✓ $NO_3^- \longrightarrow NO$: 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