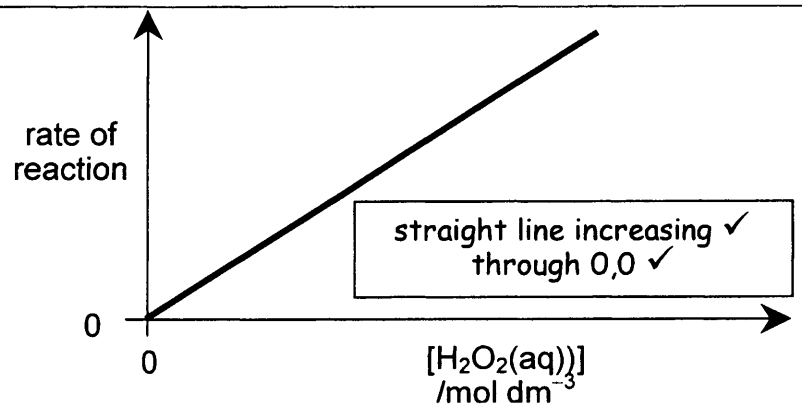
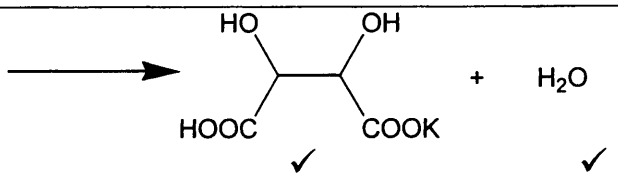
Question	Expected Answers	Marks
1 (a)	$K_c = \frac{[CH_3COOC_2H_5]\,[H_2O]}{[CH_3COOH]\,[C_2H_5OH]}$ ✓✓ *award 1 mark if upside down*	[2]
(b) (i)	<table><tr><td>CH_3COOH</td><td>C_2H_5OH</td><td>$CH_3COOC_2H_5$</td><td>H_2O</td></tr><tr><td>6.0</td><td>12.5</td><td>0</td><td>0</td></tr><tr><td>1</td><td>7.5</td><td>5</td><td>5</td></tr></table> ✓ ✓	[2]
(ii)	$K_c = \frac{5 \times 5}{1 \times 7.5}$ = 3.3 ✓ no units ✓ (or ecf based on answers to (i) and/or (a))	[2]
(c)	leave experiment longer ✓ monitor compositions and repeat until constant value ✓	[2]
(d) (i)	more $CH_3COOC_2H_5$ & H_2O / less CH_3COOH & C_2H_5OH ✓ equilibrium ⟶ right ✓ AW	[2]
(ii)	K_c stays same ✓	[1]
(e)	stays the same/ catalyst does not shift equilibrium position ✓ forward & reverse reactions altered by same amount/ equilibrium achieved in less time ✓	[2]
(f) (i)	equilibrium ⟶ left ✓ more reactants / less products ✓	[2]
(ii)	forward reaction is exothermic ✓	[1]
		Total: 16

Question	Expected Answers	Marks
2 (a)	$H_2O_2 + 2I^- + 2H^+ \longrightarrow I_2 + 2H_2O$ equation includes H_2O, I^-, H^+ as reactants and I_2 as product ✓ equation balanced ✓	[2]
(b) (i)	Exp 2 has twice $[I^-]$ as Exp 1 and rate has quadrupled ✓, so order = 2 with respect to I^- ✓ Exp 3 has twice $[H^+]$ as 2 and rate is unchanged ✓, so order = 0 with respect to H^+ ✓.....AW	[4]
(ii)	rate = $k\,[H_2O_2]\,[I^-]^2$ ✓✓ 1 mark for: rate = k x concs (ecf from (i))	[2]
(iii)	k = rate/$[H_2O_2][I^-]^2$ ✓(ecf from (ii)) From one of expts, e.g. Exp 1: k = $1.15 \times 10^{-6}/(0.01)(0.01)^2$ = 1.15 ✓ $dm^6\ mol^{-2}\ s^{-1}$ ✓ (ecf from (ii))	[3]
(c)		[2]
(d) (i)	$2H_2O_2 \longrightarrow 2H_2O + O_2$ ✓	[1]
(ii)	1 dm^3 $H_2O_2 \longrightarrow$ 20 dm^3 O_2 ✓ amount of O_2 = 20/24 mol ✓ concentration of H_2O_2 = 2 x 20/24 = 1.67 mol dm^{-3} ✓	[3]
		Total: 17

Question	Expected Answers	Marks
3 (a) (i)	a proton donor ✓	[1]
(ii)	partially dissociates ✓	[1]
(iii)	$pH = -\log[H^+]$	[1]
(iv)	A solution that minimises changes/resists change in pH after addition of acid/alkali ✓ NOT 'maintains constant pH' or 'cancel out'	[1]
(b)	H_2CO_3 reacts with added alkali / added alkali reacts with H^+ / $H^+ + OH^- \longrightarrow H_2O$ ✓ The base or HCO_3^- reacts with added acid ✓ $H_2CO_3 + OH^- \longrightarrow HCO_3^- + H_2O$ ✓ $HCO_3^- + H^+ \longrightarrow H_2CO_3$ ✓.....AW QoWC: equilibrium position moves to counteract change / explanation in terms of le Chatelier's principle ✓	[4] [1]
(c)	$K_a = \frac{[H^+]\,[HCO_3^-(aq)]}{[H_2CO_3(aq)]}$ ✓ $[H^+] = 10^{-pH}$ ✓ $= 10^{-7.4} = 3.98 \times 10^{-8}$ ✓ $\frac{[HCO_3^-(aq)]}{[H_2CO_3(aq)]} = \frac{K_a}{[H^+]} = \frac{4.17 \times 10^{-7}}{3.98 \times 10^{-8}} = 10.5$ ✓	[4]
		Total: 13

Question	Expected Answers	Marks
4 (a) (i)	crude oil ✓	[1]
(ii)	$C_4H_{10} + 3\frac{1}{2}O_2 \longrightarrow C_4H_2O_3 + 4H_2O$ C_4H_{10} , O_2 & $C_4H_2O_3$ ✓ all correct and balanced ✓	[2]
(iii)	moles butane = 30 x 1 000/24 = 1 250 ✓ M_r maleic anhydride = 98 ✓ mass maleic anhydride = moles x M_r = 1 250/1000 x 98 kg 122.5 kg ✓	[3]
(b)	molecular formula = $C_4H_6O_6$ ✓ empirical formula = $C_2H_3O_3$ ✓ (award both marks if only empirical formula is shown)	[2]
(c) (i)	 ✓ ✓	[2]
(ii)	any chemical that reacts: e.g. metal more reactive than Pb / carbonate / carboxylic acid / alcohol / hydrogen halide ✓ observation to match chemical added ✓ equation to match chemistry of chemical added; products ✓ balanced ✓	[4]
		Total: 14