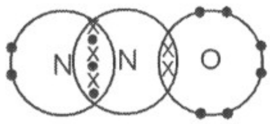
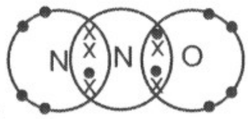
Question	Expected Answers	Marks
1 (a)	partial dissociation: $HCOOH \rightleftharpoons H^+ + HCOO^-$ ✓	[1]
(b) (i)	pH = –log (1.55 x 10^{-3}) = 2.81/2.8 ✓ [H^+] deals with negative indices over a very wide range/ pH makes numbers manageable /removes very small numbers ✓	[2]
(ii)	$K_a = \frac{[H^+(aq)]\,[HCOO^-(aq)]}{[HCOOH(aq)]}$ ✓ (state symbols not needed)	[1]
(iii)	$K_a = = \frac{[H^+(aq)]^2}{[HCOOH(aq)} = \frac{(1.55 \times 10^{-3})^2}{0.015}$ ✓ = 1.60 x 10^{-4} (mol dm^{-3})✓ pK_a = -log K_a = -log (1.60 x 10^{-4}) = 3.80 ✓	[3]
(iv)	Percentage dissociating = $\frac{(1.55 \times 10^{-3}) \times 100}{0.015}$ = 10.3 % / 10% ✓ *(working not required)*	[1]
(c) (i)	$HCOOH + NaOH \longrightarrow HCOONa + H_2O$ ✓ *state symbols not needed*	[1]
(ii)	n(HCOOH) = 0.0150 x 25.00/1000 = 3.75 x 10^{-4} ✓ volume of NaOH(aq) that reacts is 30 cm^3✓ so [NaOH] = 3.75 x 10^{-4} x 1000/30 = 0.0125 mol dm^{-3} ✓	[2]
(iii)	$K_w = [H^+(aq)][OH^-(aq)]$ ✓ pH = -log(1 x 10^{-14}/0.0125) = 12.10/12.1 ✓ (calc 12.09691001)	[3]
(iv)	metacresol purple ✓ pH range coincides with pH change **during sharp rise** OR pH 6-10 /coincides with equivalence point/end point ✓	[2]
		Total: 16

Question			Expected Answers	Marks
2	(a)		$K_c = \frac{[HI]^2}{[H_2]\,[I_2]}$ ✓	[1]
	(b)	(i)	H_2: 0.30, 0.14 ✓; I_2: 0.20, 0.04; HI: 0, 0.32 ✓	[2]
		(ii)	$K_c = \frac{0.32^2}{0.14 \times 0.04}$ = 18.28571429 ✓ = 18 (to 2 sig figs) ✓ no units ✓ (or ecf based on answers to (i) and/or (a))	[3]
	(c)		K_c is constant ✓ Composition of mixture is the same ✓	[2]
	(d)		(Forward) reaction is exothermic (ora) ✓ because equilibrium moves to the left / K_c is less ✓	[2]
	(e)	(i)	$I_2(aq) + H_2S(g) \longrightarrow 2HI(aq) + S(s)$ species and balance ✓ state symbols: accept (s) for I_2; (aq) for H_2S ✓	[2]
		(ii)	amount I_2 reacted = 1.89 mol / HI formed = 3.44 mol ✓ theoretical amount HI produced = 3.78 mol/484 g ✓ % yield = $\frac{3.44 \times 100}{3.78}$ or $\frac{440 \times 100}{484}$ = 91.0 % ✓	[3]
		(iii)	$[HI] = \frac{3.44 \times 1000}{750}$ = 4.58/4.59 mol dm^{-3} ✓ pH = –log 4.59 = –0.66 ✓	[2]
				Total: 17

Question	Expected Answers	Marks
3	From graph, constant half-life ✓ Therefore 1st order w.r.t. $[CH_3COCH_3]$ ✓	[2]
	From table, rate doubles when $[H^+]$ doubles ✓ Therefore 1st order w.r.t. $[H^+]$ ✓	[2]
	From table, rate stays same when $[I_2]$ doubles ✓ Therefore zero order w.r.t. $[I_2]$ ✓ Order with no justification does **not** score.	[2]
	rate = $k[H^+][CH_3COCH_3]$ ✓ (from all three pieces of evidence) $k = \frac{\text{rate}}{[H^+][CH_3COCH_3]} \;/\; \frac{2.1 \times 10^{-9}}{0.02 \times 1.5 \times 10^{-3}}$ ✓ $= 7.0 \times 10^{-5}$ ✓ $dm^3\ mol^{-1}\ s^{-1}$ ✓ accept 7×10^{-5}	[4]
	rate determining step involves species in rate equation ✓ two steps that add up to give the overall equation ✓ The left hand side of a step that contains the species in rate-determining step ✓ i.e., for marking points 2 and 3: $CH_3COCH_3 + H^+ \longrightarrow [CH_3COHCH_3]^+$ $[CH_3COHCH_3^+] + I_2 \longrightarrow CH_3COCH_2I + HI + H^+$	[3]
	organises relevant information clearly and coherently, using specialist vocabulary where appropriate Use of the following four words/phrases: constant, half-life, order, doubles/x2 ✓	[1]
		Total: 14

Question			Expected Answers	Marks
4	(a)	(i)	(+)1 ✓	[1]
		(ii)	 or  ✓ Look for atoms bonded together. AND other lone pairs.	[1]
	(b)	(i)	$C_{13}H_{18}O_2$ ✓	
		(ii)	any chemical that reacts to produce gas: e.g. carbonate and CO_2 ✓ accept: metal more reactive than Pb and H_2 balanced equation to match chemical added ✓	[3]
	(c)		M_r(Lidocaine) = 236 ✓ Moles Novocaine = $100 \times 10^{-3}/236 = 4.24 \times 10^{-4}$ ✓ Concentration of Novocaine = $4.24 \times 10^{-4} \times (1000/5)$ = 0.0847/0.0848/0.085 mol dm^{-3} ✓	[3]
	(d)		mass $C = 12 \times \frac{3.74}{44.0}$ = 1.02 g / moles $CO_2 = \frac{3.74}{44}$ = 0.085 mol ✓ mass $H = \frac{2}{18} \times 0.918 = 0.102$ g / moles $H_2O = \frac{0.918}{18}$ = 0.051 mol ✓	[2]
			ratio $C : H = \frac{1.02}{12} : \frac{0.102}{1} = 0.0850 : 0.102 = 5 : 6 / 10 : 12$/ ratio $CO_2 : H_2O = 5 : 3 / 10 : 6$ ✓ mass $O = 1.394 - (1.020 + 0.102) = 0.272$ g / using 1.394 g eugenol and $M_r = 164$, shows that 1 molecule contains 2 atoms of O ✓	[2]
			$\therefore$ molecular formula = $C_{10}H_{12}O_2$ ✓	[1]
				Total: 13