Abbreviations, annotations and conventions used in the Mark Scheme	/ = alternative and acceptable answers for the same marking point ; = separates marking points NOT = answers which are not worthy of credit ( ) = words which are not essential to gain credit ___ = (underlining) key words which **must** be used to gain credit ecf = error carried forward AW = alternative wording ora = or reverse argument

Question	Expected Answers	Marks
1 (a)	$K_p = \frac{p(SO_3)^2}{p(SO_2)^2 \times p(O_2)}$ ✓✓ 1 mark for correct powers but wrong way up. 1 mark for square brackets	[2]
(b)	An increase in pressure moves equilibrium to the right because there are less gaseous moles on the right hand side ✓ Increased pressures are expensive to generate/safety problems with walls of containers/enables gases to flow ✓ K_p gets less with increasing temperature ✓ SO_2 and O_2 increase/SO_3 decreases ✓ Equilibrium ⟶ left to oppose increase in temperature ✓ Forward reaction is exothermic or ΔH is –ve /reverse reaction is endothermic or ΔH is +ve because K_p gets less with increasing temperature ✓ QoWC: organises relevant information clearly and coherently, using specialist vocabulary where appropriate ✓	[6] [1]
(c)	$3.0 \times 10^2 = \frac{p(SO_3)^2}{10^2 \times 50}$ ✓ $p(SO_3) = \sqrt{(3.0 \times 10^2 \times 10^2 \times 50)} = 1225$ kPa ✓ $\%(SO_3) = 100 \times 1225 / (1225 + 10 + 50) = 95\%$ ✓	[3]
(c) (i)	$2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2$ ✓✓ ZnS, O_2 as reactants and SO_2 as a product: 1st mark. ZnO and balance: 2nd mark	[2]
(ii)	ZnS is more available than S. ✓	[1]
		Total: 15

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Question	Expected Answers	Marks
2 (a) (i)	O_3: 1 and C_2H_4 ✓	[1]
(ii)	2 ✓	[1]
(iii)	rate = $k[O_3][C_2H_4]$ ✓	[1]
(b) (i)	measure gradient/tangent ✓ at t = 0/start of reaction ✓	[2]
(ii)	$k = \frac{\text{rate}}{[O_3][C_2H_4]}$ ✓ $k = \frac{1.0 \times 10^{-12}}{0.5 \times 10^{-7} \times 1.0 \times 10^{-8}} = 2 \times 10^3$ ✓ $dm^3\ mol^{-1}\ s^{-1}$ ✓	[3]
(iii)	2 mol CH_2O forms for every 0.5 mol O_2 / stoichiometry of CH_2O : O_2 is **not** 1:1 ✓	[1]
(iv)	rate increases ✓ k increases ✓	[2]
(c) (i)	each atom has two unpaired electrons ✓	[1]
(ii)	2 oxygen atoms bonded by double bond ✓ third oxygen bonded by a covalent bond and outer shells correct ✓ For 2nd mark, all O atoms must have an octet. A triangular molecule would have 3 single covalent bonds for 1st mark but the origin of each electron must be clear for 2nd mark	[2]
(iii)	amount of O_3 in 150 kg = $150 \times 10^3/48 = 3.13 \times 10^3$ mol ✓ amount of Cl radicals in 1 g = 1 /35.5 = 2.82×10^{-2} mol ✓ 1 mol Cl destroys $3.13 \times 10^3/2.82 \times 10^{-2} = 1.11 \times 10^5$ mol O_3 1 Cl radical destroys 1.11×10^5 O_3 molecules ✓ (calculator: 110937)	[3]
		Total: 17

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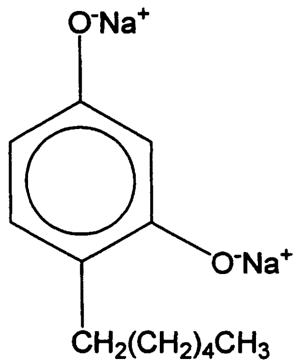
Question	Expected Answers	Marks
3 (a) (i)	proton donor ✓	[1]
(ii)	partially dissociates ✓	[1]
(b)	$C_6H_5OH(aq)$ + $OH^-(aq)$ ⇌ $C_6H_5O^-(aq)$ + $H_2O(l)$ acid 1 base 2 ✓ base 1 acid 2 ✓ *1 mark for each acid-base pair*	[2]
(c) (i)	$K_a = \frac{[C_6H_5O^-][H^+]}{[C_6H_5OH]}$ ✓	[1]
(ii)	concentration = 38/94 ✓ = 0.40 mol dm^{-3} ✓ *(first mark for M_r of phenol - incorrect answer here will give ecf for remainder of question)* $1.3 \times 10^{-10} \approx \frac{[H^+(aq)]^2}{0.40}$ ✓ *('=' sign is acceptable)* $[H^+] = \sqrt{\{(1.3 \times 10^{-10}) \times (0.40)\}} = 7.2 \times 10^{-6}$ mol dm^{-3} ✓ pH = $-\log[H^+]$ = $-\log 7.2 \times 10^{-6}$ = 5.14 ✓ ***3 marks:*** $[H^+]$✓; pH expression✓; calc of pH from $[H^+]$ ✓ ***Common errors:*** Without square root, answer = 10.28 ✓✓× Use of 38 as molar concentration does not score 1st 2 marks. This gives an answer of 4.15 for 3 marks ✓✓✓	[5]
(d)	 / NaOH /Na✓ weak acid/base pair mixture formed ✓ *On structure, 1 mark for O Na on either or both phenol groups.*	[2]
		Total: 12

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Question	**Expected Answers**	**Marks**
4 (a)	graphs are of pH against volume acid/alkali added with scale and units ✓ sharp rise between two slight rises ✓ equivalent point > 7 ✓ sharp rise after addition of 25 cm^3 of alkali ✓ start pH = 2.9 ✓ finish pH = 12 → 13 ✓	[6]
(b)	phenolphthalein changes colour in the pH range corresponding to the sharp rise in the titration curve ✓ methyl orange changes colour **before** the sharp rise ✓	[2]
(c)	sharp rise in pH after addition of 12.5 cm^3 NaOH ✓ pH start is higher than 2.9 ✓	[2]
(d)	moles HCl in 23.2 cm^3 = 0.200 x 23.2/1000 = 4.64×10^{-3} ✓ moles B in 25 cm^3 = moles HCl = 4.64×10^{-3} ✓ moles B in 250 cm^3 = $4.64 \times 10^{-3} \times 10 = 4.64 \times 10^{-2}$ ✓ 4.64×10^{-2} mol B has a mass of 4.32 g molar mass of B = $4.32/4.64 \times 10^{-2}$ = 93 g mol^{-1} ✓ 93 - 16 = 77 ✓ Therefore B is phenylamine / $C_6H_5NH_2$ ✓ *There may be other valid structures that are amines. These can be credited provided that everything adds up to 93.* *Answer could be a primary, secondary or tertiary amines.*	[6]
		Total: 16