Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1(a)	C		1

Question Number	Correct Answer	Reject	Mark
1(b)	A		1

Question Number	Correct Answer	Reject	Mark
2	D		1

Question Number	Correct Answer	Reject	Mark
3	A		1

Question Number	Correct Answer	Reject	Mark
4(a)	C		1

Question Number	Correct Answer	Reject	Mark
4(b)	A		1

Question Number	Correct Answer	Reject	Mark
5	A		1

Question Number	Correct Answer	Reject	Mark
6	B		1

Question Number	Correct Answer	Reject	Mark
7	B		1

Question Number	Correct Answer	Reject	Mark
8	D		1

Question 9: N/A

Question 10: N/A

Question 11: N/A

Question 12: N/A

Question 13: N/A

Question Number	Correct Answer	Reject	Mark
14	B		1

Question 15: N/A

Question 16: N/A

Question 17: N/A

Question 18: N/A

Question 19: N/A

Question Number	Acceptable Answers	Reject	Mark
20(a)	(Greater yield) as fewer moles/molecules (of gas) on RHS OR 3 moles/molecules on left but only 1 on right **(1)** ALLOW arguments in terms of K_p remaining constant Disadvantage: Extra cost of (building) equipment (to withstand higher pressure)/ thicker pipes/compressor/maintaining equipment **(1)** OR Higher cost **of energy** needed for compression **(1)** IGNORE references to explosion	Just (higher) cost	**2**

Question Number	Acceptable Answers	Reject	Mark
20(b)(i)	(Reaction is exothermic) so the value of $\Delta S_{surroundings}$ becomes more positive/larger (at 100 °C) **(1)** Therefore ΔS_{total} becomes more positive/larger/less negative(at 100 °C) **(1)** Second mark consequential on first		**2**

Question Number	Acceptable Answers	Reject	Mark
20(b)(ii)	(Higher temperature gives a) faster rate of reaction /more particles have $E \geq E_a$ (ALLOW more successful collisions (per second) IGNORE references to yield		**1**

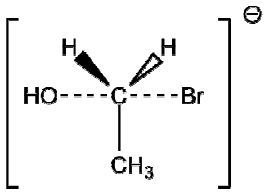
Question Number	Acceptable Answers	Reject	Mark
20(c)	Remove methanol/the product (as it is formed) **(1)** Recycle/reuse **unreacted** reactants **(1)** IGNORE references to catalyst and increasing amounts of reactants		**2**

Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	k = (1.54 x 10^{-6}) ÷ (0.1 x 0.15) **(1)** (= 1.0267 x 10^{-4}) = 1.03 x 10^{-4} **(1)** must be to 3 SF dm^3 mol^{-1} s^{-1} **(1)** Unit mark is stand alone and units can be in any order Correct answer with units but no working **(3)** marks	 1.02 x 10^{-4}	**3**

Question Number	Acceptable Answers	Reject	Mark

21(a)(ii)	If correct unrounded answer to (a) (i) stored in calculator then
	4.1067 x 10^{-8} = 4.1 x 10^{-8} (mol dm^{-3} s^{-1})
	
	OR
	
	If 1.0267 x 10^{-4} used then
	4.1068 x 10^{-8} = 4.1 x 10^{-8} (mol dm^{-3} s^{-1})
	
	OR
	
	If 1.03 x 10^{-4} used then
	4.12 x 10^{-8} = 4.1 x 10^{-8} (mol dm^{-3} s^{-1})
	
	IGNORE sf except 1sf
	
	IGNORE units even if incorrect
	TE from (a)(i)
			1

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	2(nd)/second/two/(1 + 1) = 2 (order)		**1**

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	 Structure **(1)** ALLOW structure without wedged bonds Dotted bonds must be shown and OH and Br must be on opposite sides with a C-C or C-H bond between them Charge **(1)** Charge mark can be awarded for a near miss with a single error in the structure (e.g. one hydrogen atom missing) ALLOW –ve charge shown as δ– on both OH and Br Brackets not essential ALLOW –ve charge to be anywhere on the structure IGNORE δ+ on carbon atom		**2**

Question Number	Acceptable Answers	Reject	Mark
21(c)(i)	3.00×10^{-3} **(1)** IGNORE sf for 1/T −5.58 **(1)** IGNORE sf except 1sf	-5.60	**2**

Question Number	Acceptable Answers	Reject	Mark
21(c)(ii)	Appropriate scale **(1)** Plotted points **must** cover at least half of the graph paper on each axis. Points plotted correctly **and** straight line drawn **(1)** through all points Gradient = —10230 ± 500 **(1)** Example E_a = 10230 x 8.31**(1)** allow TE from incorrect gradient E_a = (+) 85.0 kJ(mol^{-1})/(+) 85 000 J (mol^{-1}) **(1)** 3 sf E_a range from 80.9 to 89.2 kJ mol^{-1} ALLOW TE from incorrect gradient IGNORE SF except 1	K^{-1}	**5**

Section C

Question Number	Acceptable Answers	Reject	Mark
22 (a)(i)	(+)186.2 (J mol^{-1} K^{-1})		**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	(266.9 + 186.2) – 310.1 **(1)** **=** + 143 (J mol^{-1} K^{-1}) **(1)** – 143 scores (1) Correct answer with sign and no working scores (2) marks ALLOW TE from (i)		**2**

Question Number	Acceptable Answers	Reject	Mark
22(a)(iii)	Yes, as reaction produces 2 molecules/moles from one/more molecules/moles **(1)** (and) all products are gases **(1)** IGNORE references to volumes More moles/molecules of **gas produced** scores (2) OR Yes, (as the reaction is endothermic) $\Delta S_{surroundings}$ is negative **(1)** Since the reaction takes place/goes (spontaneously) ΔS_{total} is positive and therefore ΔS_{system} is positive **(1)** ALLOW TE from (a)(ii) i.e. 'No, as….'		**2**

Question Number	Acceptable Answers	Reject	Mark
22(a)(iv)	$\Delta S_{surr} = -\Delta H/T$ **(1)** $= -71900/700$ $= -102.7$ **J** K^{-1} mol^{-1}/− 0.1027 **kJ** K^{-1} mol^{-1} **(1)** Correct answer and sign with no working scores (2) — 0.103 **J** K^{-1} mol^{-1} scores (1) **Third mark** So ΔS_{total} is positive (so reaction is feasible) **(1)** OR ΔS_{total} = **+**40.3 J K^{-1} mol^{-1} (so reaction is feasible) **(1)** ALLOW TE from (a)(ii)	1 or 2 sf	**3**

Question Number	Acceptable Answers	Reject	Mark
22(a)(v)	$\Delta S_{total} = 0$ OR $\Delta S_{surroundings} = —143$ **(1)** $T = \Delta H \div \Delta S_{surroundings}$ OR T = (—) 71900 ÷ (—)143 **(1)** = 502.8 (K) **(1)** IGNORE sf except 1sf Correct answer with no working scores (3) ALLOW 0.5028 (K) for (2) marks ALLOW — 502.8 (K) for (2) marks ALLOW — 0.5028 (K) for (1) mark ALLOW TE from (a)(ii) If the calculation is not based on $\Delta S_{total} = 0$ then a maximum of (2) marks can be awarded if done correctly		**3**

Question Number	Acceptable Answers	Reject	Mark
22(b)	The catalyst is in a different state/phase to the reactants **(1)** IGNORE references to products **Any two from** It provides an alternative (reaction) route/mechanism/gases adsorbed on catalyst surface **(1)** Of lower activation energy/weakens bonds in reactants **(1)** Greater proportion of molecules have E ≥ Ea **(1)**		**3**

Question Number	Acceptable Answers	Reject	Mark
23 (a)(i)	(Ka =) $[H^+][C_6H_5COO^-]/[C_6H_5COOH]$ Penalise missing charges ALLOW $[H_3O^+]$ in place of $[H^+]$ IGNORE state symbols and units even if incorrect	Ka = $[H^+]^2/[C_6H_5COOH]$	**1**

Question Number	Acceptable Answers	Reject	Mark
23(a)(ii)	$[H^+] = \sqrt{(6.3 \times 10^{-5} \times 0.0025)}$ (1) pH = − log $\sqrt{(6.3 \times 10^{-5} \times 0.0025)}$ = 3.4 **(1)** Answer without working scores (2) marks 6.8 scores (1) IGNORE sf except 1	answer if units given	**2**

Question Number	Acceptable Answers	Reject	Mark
23(b)	(pH) range (of indicator) 3.8 to 5.4 OR pK_{in} = 4.7 **(1)** Bubble bath is (initially yellow since) pH less than 3.8 / is 3.4 **(1)** Adding of water/dilution (of acid) causes pH to rise/ means $[H^+]$ decreases **(1)** Hence pH rises to ≥ 5.4 so blue/changes colour **(1)** If a(ii) pH>3.8 and <5.4 then loses second marking point but can score other marking points. If a(ii) pH>5.4 then can score first and third marking points only	Water neutralizes acid	**4**

Section A

Question Number	Correct Answer	Mark
24	D	**1**

Question Number	Correct Answer	Mark
25	C	**1**

Question Number	Correct Answer	Mark
26	A	**1**

Question Number	Correct Answer	Mark
27	A	**1**

Question Number	Correct Answer	Mark
28	C	**1**

Question Number	Correct Answer	Mark
29	C	**1**

Question Number	Correct Answer	Mark
30	B	**1**

Section B

Question Number	Acceptable Answers	Reject	Mark
31 (a)(i)	**Copper:** 0 to +2/2+/2^+/II/2 **(1)** **Nitrogen:** +5/5+/5^+/V/5 to +4/4+/4^+/IV/4 **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
(a)(ii)	$Cu \rightarrow Cu^{2+} + 2e^{(-)}$ OR $Cu - 2e^{(-)} \rightarrow Cu^{2+}$ **(1)** $Cu[(H_2O)_6]^{2+}$ OK if 6 waters shown on l.h.s. $NO_3^- + 2H^+ + e^{(-)} \rightarrow NO_2 + H_2O$ OR $2NO_3^- + 4H^+ + 2e^{(-)} \rightarrow 2NO_2 + 2H_2O$ **(1)** OR $2NO_3^- + 4H^+ + 2e^{(-)} \rightarrow N_2O_4 + 2H_2O$ **(1)** Ignore the full equation if it is given as well Allow equations written as reverse of above Ignore state symbols even if wrong Allow $\rightleftharpoons$ for $\rightarrow$		**2**

Question Number	Acceptable Answers	Reject	Mark
(a)(iii)	(electrode potential) values are for standard conditions **(1)** **nitric acid** is concentrated / not 1 mol dm^{-3} / not 1 M **(1)** Allow temperature not stated for second mark	NO_3^- are not 1 mol dm^{-3} Any reference to loss of NO_2	**2**

Question Number	Acceptable Answers	Reject	Mark
(b)(i)	initially a (pale/light) **blue precipitate (1)** Allow blue solid Ignore white precipitate (re-dissolves in excess to form) a (deep) blue **solution (1)** Stand alone mark Accept any shade of blue except greenish-blue	Any colour (other than blue) precipitate in blue solution	**2**

Question Number	Acceptable Answers	Reject	Mark
(b)(ii)	$Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$ **(1)** $Zn^{2+}(aq) + 2OH^-(aq) \rightarrow Zn(OH)_2(s)$ **(1)** $Zn(OH)_2(s) + 2OH^-(aq) \rightarrow Zn(OH)_4^{2-}(aq)$ **(1)** If two previous equations combined correctly then **(1)** only : $Zn^{2+} + 4OH^- \rightarrow Zn(OH)_4^{2-}$ **Allow** $Zn(OH)_2(s) + 2OH^-(aq) \rightarrow ZnO_2^{2-}(aq) + 2H_2O(l)$ OR $Zn(OH)_2(s) + 4OH^-(aq) \rightarrow Zn(OH)_6^{4-}(aq)$ OR equivalent non-ionic equations, including those with Zn^{2+} + 2NaOH etc OR Correct balanced equations starting with hexaqua or tetraqua cations ALLOW the hydroxides to be shown as e.g. $Zn(OH)_2(H_2O)_4$ (s) provided that the whole equation balances. Penalise missing /incorrect state symbols on product once only. Ignore other state symbols		**3**

Question Number	Acceptable Answers	Reject	Mark
(b)(iii) QWC	**First 2 marks:** zinc **hydroxide/oxide** amphoteric because it reacts with alkali (to give a solution of a zincate) **(1)** and reacts with acid (to give a salt) **(1)** zinc hydroxide **is / acts as** both an acid and an alkali – scores **(1)** only **Third mark:** hexaquazinc or hydrated zinc ions exchanged water for ammonia or other named ligand **(1)** OR $Zn(H_2O)_6^{2+} + 4NH_3 \rightarrow$ etc **(1)** Allow any number of ammonias from 1 to 6 Allow balanced equations, ionic or full. Ligand exchange reaction must start with a complex ion **Note:** If zinc mentioned initially but equation refers to a correct compound then credit should be given If equations wrong but words are correct then ignore equations	Reference to zinc ions or zinc metal Do not allow deprotonation	**3**

Question Number	Acceptable Answers	Reject	Mark
(c)(i)	$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$ Ignore state symbols even if wrong.	Non-ionic equation.	**1**

Question Number	Acceptable Answers	Reject	Mark
(c)(ii) **QWC**	Amount thiosulphate = 0.0331 dm^3 x 0.1 mol dm^{-3} = 0.00331 mol **(1)** = amount of copper(II) ions in 25 cm^3 portion **(1)** ∴ amount Cu = 10 x 0.00331= 0.0331 mol in total **(1)** ∴ mass Cu = 0.0331 mol x 63.5 g mol^{-1} **(1)** = 2.102 g ∴ % copper = (2.102 x 100)÷ 3.00 **(1)** = 70.1% **(1)** to **3 s.f. only** Mark consequentially but if % > 100 then (-1) If equation in (i) is incorrect but used correctly in part (ii) then all marks can be scored unless answer > 100% Correct answer can score 6 marks irrespective of the stoichiometry of the equation in (c)(i) If candidates uses 64 for molar mass of Cu final answer will be 70.6; scores max of 5	70.06 or 70.0	**6**

Question Number	Acceptable Answers	Reject	Mark
(c)(iii)	some reagent used to fill the jet (which does not react with the iodine solution) **and so** the titre is too high **(1)** and hence the percentage value would be too high **(1)** Allow only if the titre is said to be high If the titre is thought to be too low then allow percentage value too low for 2nd mark **(1)**		**2**