CHEMISTRY A LEVEL PAPER 1 MARK SCHEME

Question number	Answer	Additional guidance	Marks
1(a)	B		**1**
1(b)	B		**1**
1(c)	C		**1**
1(d)(i)	An explanation that makes reference to the following points: • the shape is V-shaped/bent (1) • because the three electron pairs on Sn repel one another (1)	First marking point can be awarded for a correctly-drawn diagram	**2**
1(d)(ii)	• prediction: any value between 95 and 119º (1) • justification: lone pair – bond pair repulsion is greater than bond pair – bond pair repulsion (and hence the angle is less than 120º) (1)		**2**

(Total for Question 1 = 7 marks)

Question number	Answer	Additional guidance	Marks
2(a)	D		**1**
2(b)	B		**1**
2(c)	D		**1**
2(d)	• order: GZ > DX > EY (1) Justification: • the ions in GZ have higher charges (than those in both EY and DX) (1) • the ions in DX are smaller than those in EY (1)		**3**
2(e)	• construction of balanced cycle (1) • substitution and evaluation of 2^{nd} IE (1)	Example calculation $-2258 = -590 - 2^{nd}\text{ IE} + 2(349) - 178 - 2(122) - 796$ hence 2^{nd} IE = (+) 1148 (kJ mol^{-1}) correct answer, no working scores 2 marks	**2**

(Total for Question 2 = 8 marks)

Question number	Answer	Additional guidance	Marks
3(a)	• (V) $(1s^2 2s^2 2p^6 3s^2) 3p^6 3d^3 4s^2$ (1) • (V^{3+}) $(1s^2 2s^2 2p^6 3s^2) 3p^6 3d^2$ (1)	Allow $4s^2 3d^3$	**2**
3(b)(i)	An explanation that makes reference to the following points: • $E^{\ominus}$ of redox system 5 is more negative / less positive than that of both redox systems 4 and 3 (but not than that of redox systems 2 and 1) (1) • therefore SO_2 releases electrons to / reduces VO_2^+ to VO^{2+} and then VO^{2+} to V^{3+} (1) • (yellow to) blue <u>then</u> green (1)	Accept explanations based on calculating $E^{\ominus}_{cell}$ for the reactions Accept correct use of anticlockwise rule Ignore green colour before blue	**3**
3(b)(ii)	The reaction is **<u>not</u>** feasible because: • $E^{\ominus}$ of redox system 2 is less negative than that of redox system 1 (1) • therefore V^{2+} ions in system 2 will not release electrons to the V^{2+} ions in system 1 (1)	Accept explanations based on calculating $E^{\ominus}_{cell}$ for the reactions Accept correct use of anticlockwise rule	**2**

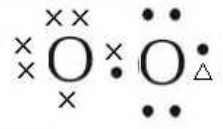
(Total for Question 3 = 7 marks)

Question number	Answer	Additional Guidance	Marks
4(a)	• axes: correct way round, labelled, suitable scale (1) • all points plotted correctly to nearest gridline AND straight line through first 3 points, straight line through last 3 points, and the two lines intersect (1)	The scale is suitable if the distance between the first point plotted and the last point plotted covers more than half of the graph paper on each axis.	**2**
4(b)(i)	10 (cm^3) (1)	Award mark for a value read correctly from the candidate's graph	**1**
4(b)(ii)	(0.005 x 0.5) = 2.5(0) x 10^{-3} / 0.0025 (mol) (1)		**1**
4(b)(iii)	(0.010 x 1.00) = 1 x 10^{-2} / 0.01 (mol) (1)	Answer to (iii) csq on (ii)	**1**
4(b)(iv)	x = 4 and y = 2 (1)	Answer to (iv) csq on (i) and (ii), but x + y must total 6	**1**
4(c)	$Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$ • correctly balanced equation (1) • state symbols (1)	Allow $[Cu(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(H_2O)_4(OH)_2(s) + 2H_2O(l)$	**2**

(Total for Question 4 = 8 marks)

Question number	Answer	Additional guidance	Marks
5(a)	$Cl_2 + 2NaOH \rightarrow NaOCl + NaCl + H_2O$ (1)	Accept $Cl_2 + 2OH^- \rightarrow OCl^- + Cl^- + H_2O$ Ignore state symbols	**1**
5(b)	An explanation that makes reference to the following points: • Cl has oxidation number +4 to in ClO_2 (1) • Cl (in ClO_2) changes oxidation number to +3 (ClO_2^-) and +5 (ClO_3^-) (1) • (therefore) chlorine/it (in ClO_2) has been both oxidised and reduced (1)	 Accept 4+ Accept 3+ and 5+ Allow answers in any order	**3**
5(c)(i)	A		**1**
5(c)(ii)	An answer that makes reference to the following points: • Mn changes from +7 to +2 and Cl changes from -1 to 0 (1) • therefore ratio is MnO_4^- to $5Cl^-$ /the ratio of MnO_4^- to Cl^- is 1 to 5 (1)	 Accept 7+ and 2+ Accept 1–	**2**
5(d)(i)	An explanation that makes reference to the following points: • the HBr dissolves in water (in the air) (1) • and forms droplets (of hydrobromic acid) (1)		**2**
5(d)(ii)	• the (conc.) H_2SO_4 is reduced to SO_2 (1)	Accept redox	**1**

(Total for Question 5 = 10 marks)

Question number	Answer	Additional guidance	Marks
6(a)	• determines number of mol of CO_2 produced (1) • calculates number of mol NaO_2 in 880 g (1) • calculates the number of mol of CO_2 reacted with NaO_2 and hence determines the number of mol of CO_2 in excess (1) • calculation of mass of Na_2O = 248 g (1)	<u>Example of calculation</u> 2 mol glucose produces 12 mol CO_2 880 g NaO_2 = 16 mol 16 mol NaO_2 remove 8 mol CO_2 (therefore 4 mol CO_2 is excess) mass of Na_2O required is (4 x 62) = 248 g 3rd mark is csq on answers given in 1st and 2nd marks 4th mark is csq on answer given in 3rd mark Correct answer with units and no working scores 4 marks.	**4**
6(b)	An explanation that makes reference to the following points:  (1) • it is a radical because it has an unpaired electron (1)	Accept any other symbols in place of dots and crosses, including a minus sign to replace the triangle	**2**

Question number	Answer	Additional guidance	Marks
6(c)	• calculation of number of moles Na_2O_2 (= mols H_2O_2) (1) • calculation of number of moles Ce^{4+} (1) • determination of the ratio H_2O_2 : Ce^{4+} (1) • formula of cerium ion is Ce^{3+} (1)	<u>Example of answer</u> $n(Na_2O_2) = (0.403 \div 78.0) = 5.17 \times 10^{-3}$ $n(Ce^{4+}) = (24.85 \div 1000 \times 0.420)$ $= 1.04 \times 10^{-2}$ $n(Ce^{4+}) : n(H_2O_2) = 1.04 \times 10^{-2} : 5.17 \times 10^{-3}$ $= 2 : 1$ 1st and 2nd mark: accept answers to any significant figures, except 1s.f 3rd mark csq on answers given in 1st and 2nd marks 4th mark csq on answer given in 3rd mark	**4**

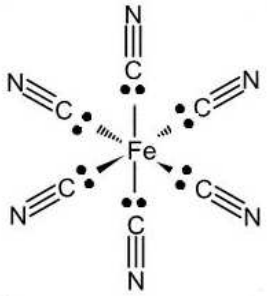
(Total for Question 6 = 10 marks)

Question number	Answer	Additional guidance	Marks
7(a)	B		**1**
7(b)(i)	• calculation of n(CO) at equilibrium and $n(H_2)$ at equilibrium (1) • converting number of moles to concentration (1) • evaluation of K_c by substitution (1) • correct answer to 3 sf (1) • units: $dm^6\ mol^{-2}$ (1)	<u>Example of calculation</u> n(CO) at equilibrium = 0.114 (mol) $n(H_2)$ at equilibrium = 0.228 (mol) $[CO] = 0.0950\ moldm^{-3}$, $[H_2] = 0.190\ moldm^{-3}$, $[CH_3OH] = 0.0717\ mol\ dm^{-3}$ $K_c = 0.0717 \div (0.0950 \times 0.190^2) = 20.9068\ldots..$ $= 20.9\ dm^6\ mol^{-2}$ Allow $mol^{-2}\ dm^6$ 3rd and 4th marks csq on answers given in 1st and 2nd marks Correct final answer to 3 sf with units but no working scores 5 marks	**5**
7(b)(ii)	An explanation that makes reference to the following points: • an increase in temperature shifts the equilibrium to the left (1) • an increase in pressure shifts the equilibrium to the right (1) • these changes produce opposing effects, so to predict the effect on the yield it is necessary to know the relative effects of each one (1)		**3**

(Total for Question 7 = 9 marks)

Question number	Answer	Additional guidance	Marks
8(a)	A		**1**
8(b)(i)	An explanation that makes reference to the following points: • stage 2 is an equilibrium reaction / only partial ionisation occurs (1) • therefore fewer hydrogen ions are formed (1)	Accept dissociation for ionisation	**2**
8(b)(ii)	• rearrangement of equation pH = - log $[H^+]$ and substitution to give final answer (1)	Example calculation: $[H^+] = 10^{-pH}$ $10^{-0.97} = 0.107$ (mol dm^{-3}) Allow 0.11 (mol dm^{-3}) Correct answer with no working scores 1 mark	**1**
8(c)	• rearrangement of K_a expression (1) • calculation of $[CH_3COOH]$ and $[CH_3COO^-]$ (1) • substitution, and evaluation of $[H^+]$ in the buffer solution (1) • conversion of $[H^+]$ to pH for buffer solution (1)	Example of calculation : $[H^+] = K_a \frac{[CH_3COOH]}{[CH_3COO^-]}$ $[CH_3COOH] = 0.333$ mol dm^{-3} and $[CH_3COO^-] = 0.167$ mol dm^{-3} $[H^+] = 1.74 \times 10^{-5} \times 0.333 / 0.167$ $= 3.48 \times 10^{-5}$ (mol dm^{-3}) so pH = -lg $3.48 \times 10^{-5} = 4.46$ Accept answers that use forms of the Henderson-Hasselbach equation Correct answer with no working scores 4 marks	**4**

(Total for Question 8 = 8 marks)

Question number	Answer	Additional guidance	Marks
9(a)(i)	A		**1**
9(a)(ii)	 • 3D shape correctly shown (1) • electron pairs shown OR all six bonds shown clearly to the carbons (1)	Charge and square brackets not required Allow dotted lines for the wedges going backwards Allow arrows to represent dative covalent bonds instead of electron pairs	**2**
9(b)	• step 1 – ligand substitution/ligand exchange (1) • step 2 – redox (1)	Allow reduction **and** oxidation	**2**
9(c)	• identification: green precipitate is iron(II) hydroxide (1) Explanation: • precipitate turns brown because iron(II) hydroxide is oxidised by oxygen (and water) in the air (1) • to form iron(III) hydroxide (1)	Allow $Fe(OH)_2$ / $Fe(H_2O)_4(OH)_2$ Allow $Fe(OH)_3$ / $Fe(H_2O)_3(OH)_3$	**3**

(Total for Question 9 = 8 marks)

Question number	Answer	Additional guidance	Marks
10(a)	An explanation that makes reference to the following points: • they get more stable down the group (1) • because the size of the cations increases/charge density of cations decreases (1) • and so carbonate ions are less polarised (1)		**3**
10(b)	• rearrangement of equation (1) • calculation of $\Delta H_{solution}$ (1)	Example of calculation $-2493 + \Delta H_{solution} = -1920 + (-2 \times 364)$ $\Delta H_{solution} = -155$ (kJ mol^{-1}) Correct sign must be given in final answer Correct answer and sign with no working scores 2 marks	**2**
10(c)(i)	An explanation that makes reference to the following points: • breaking the lattice is endothermic and the hydration of ions is exothermic (1) • (therefore the dissolving of magnesium sulphate is exothermic) because the enthalpy of hydration (of the ions) is greater in magnitude than the lattice energy (of $MgSO_4$) (1)		**2**
10(c)(ii)	• $\Delta G^{\ominus} = -87 - (298 \times -0.210)$ $= -24(.42)$ (kJ mol^{-1}) (1) • since ΔG is negative the process/reaction is spontaneous/feasible (1)		**2**

<table>
<tr><th>Question number</th><th>Answer</th><th>Additional guidance</th><th>Marks</th></tr>
<tr><td>*10(d)</td><td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5–4</td><td>3</td></tr>
<tr><td>3–2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
</td><td>Guidance on how the mark scheme should be applied:
The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).
If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td><td>6</td></tr>
</table>

<table>
<tr><th>Question number</th><th>Answer</th><th>Additional guidance</th><th>Marks</th></tr>
<tr><td>*10(d) cont.</td><td>The following table shows how the marks should be
<table>
<tr><td></td><td>Number of marks awarded for structure of answer and sustained line of reasoning</td></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout.</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning.</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured.</td><td>0</td></tr>
</table>
awarded for structure and lines of reasoning.
Indicative content
($\Delta G^{\ominus}_{solution} = \Delta H^{\ominus}_{solution} - T\Delta S^{\ominus}_{system}$)
• for $BaSO_4$: $\Delta H^{\ominus}_{solution}$ and $-T\Delta S^{\ominus}_{system}$ are both positive (1)
• for $CaSO_4$: $\Delta H^{\ominus}_{solution}$ is negative and $-T\Delta S^{\ominus}_{system}$ is positive (1)
• but the magnitude of $-T\Delta S^{\ominus}_{system}$ is greater than that of $\Delta H^{\ominus}_{solution}$ (1)
• therefore $\Delta G^{\ominus}_{solution}$ for both salts is positive (1)
• when $\Delta G^{\ominus}_{solution}$ is positive the salt is only slightly soluble (1)
• $BaSO_4$ is less soluble than $CaSO_4$ because $\Delta G^{\ominus}_{solution}$ is more positive (1)</td><td></td><td></td></tr>
</table>

(Total for Question 10 = 15 marks)