Mark Scheme (Results)

Summer 2024

Pearson Edexcel GCE
In Chemistry (9CH0)
Paper 01: Advanced Inorganic and Physical Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:

- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities. Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>1(a)</td><td>An answer that makes reference to the following points:

• first row correct (1)

• second row correct (1)

• third row correct (1)</td><td><table><tr><th>Species</th><th>Number of protons</th><th>Number of neutrons</th><th>Number of electrons</th></tr><tr><td>^{32}S</td><td>16</td><td>16</td><td>16</td></tr><tr><td>^{33}S</td><td>16</td><td>17</td><td>16</td></tr><tr><td>$^{34}S^{2-}$</td><td>16</td><td>18</td><td>18</td></tr></table>
If no marks are scored, allow 1 mark for each correct column</td><td>(3)</td></tr>
</table>

Question Number	Acceptable Answer	Additional Guidance	Mark
1(b)(i)	• calculation of missing value	<u>Example of calculation</u> (100 − 95.02 – 0.75 – 0.02 =) 4.21 (%)	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
1(b)(ii)	• correct expression for calculation of RAM **(1)** • value given to 2 decimal places **(1)**	Example of calculation RAM = $\frac{((95.02 \times 32) + (0.75 \times 33) + (4.21 \times 34) + (36 \times 0.02))}{100}$ (= 32.0925) Allow TE on 1(b)(i). = 32.09 Allow units of g mol^{-1} / g mol^{-} Allow units of g/mol Do not award any other unit Correct answer with no working scores 2	**(2)**

(Total for Question 1 = 6 marks)

Question Number	Acceptable Answer		Additional Guidance	Mark
2(a)	An explanation that makes reference to the following points:		Allow reverse arguments up the group / comparison of specific elements. Penalise 'losing an electron' or incorrect reference to oxidation once.	**(4)**
	• electron affinity becomes less negative / less exothermic / less energy is released going from chlorine to iodine / down the group	**(1)**	Allow the electron affinity becomes more positive / more endothermic going from chlorine to iodine Ignore electron affinity increases / decreases Do not award requires / produces energy	
	• atomic radius increases / number of shells increases / increased distance between the nucleus and the outer / valence electron(s) **and** there is less attraction between the nucleus and the incoming / added electron / valence electron(s)	**(1)**	Do not award any reference to ions, ionic radius, charge or charge density for M2 unless point is clearly made that ions are being formed from atoms	
	• (there is) increased shielding (from inner electron shells)	**(1)**	Allow there is an increase in repulsion between the (inner) electron shells and the incoming electron(s)	
	• (increased) shielding outweighs the effect of increasing nuclear charge **or** (increased) repulsion between the (inner) electron shells and the incoming electron outweighs the effect of increasing nuclear charge **or** (increased) distance of the outer shell / energy level outweighs the effect of increasing nuclear charge	**(1)**		

Question Number	Answer	Mark
2(b)	**The only correct answer is D** (Ca^{2+}) ***A*** *is not correct because* S^{2-} *has fewer protons than* Ca^{2+} *and has the largest ionic radius of those listed* ***B*** *is not correct because* Cl^{-} *has fewer protons than* Ca^{2+} *and has the second largest ionic radius* ***C*** *is not correct because* K^{+} *has fewer protons than* Ca^{2+} *and has the second smallest ionic radius*	**(1)**

Question Number	Answer	Mark
2(c)(i)	**The only correct answer is D** (1086, 2353, 4621, 6223, 37832) ***A*** *is not correct because these are the successive ionisation energies of a Group 3 element* ***B*** *is not correct because these are the successive ionisation energies of a transition element* ***C*** *is not correct because these are the successive ionisation energies of a Group 2 element*	**(1)**

Question Number	Answer	Mark
2(c)(ii)	**The only correct answer is C** (738, 1451, 7733, 10541, 13629) ***A*** *is not correct because these are the successive ionisation energies of a p-block element* ***B*** *is not correct because these are the successive ionisation energies of a d-block element* ***D*** *is not correct because these are the successive ionisation energies of a p-block element*	**(1)**

(Total for Question 2 = 7 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
3(a)(i)	An explanation that makes reference to the following points:		**(3)**
	• platinum / nichrome wire **(1)**	Allow NiCr for nichrome Allow silica rod Allow loop for wire Ignore inoculating / sterilising Do not award just nickel or chromium Do not award splint	
	• dip (the wire) into (concentrated) hydrochloric acid / HCl(aq) / HCl **(1)**	Allow mention of HCl((aq)) before or after dipping wire into solid eg cleaning or mixing solid and HCl((aq)) to make a paste Ignore just acid Do not award other acids Allow salt / compound / paste / solid for sample Do not award element / metal for sample	
	• dip the wire / silica rod into the sample **and** place in a (blue / roaring / non-luminous) flame **(1)**	Allow on / over / above / under the flame for 'in' Do not award reference to safety / yellow flame Do not award burn in the flame	

Question Number	Acceptable Answer	Additional Guidance	Mark
3(a)(ii)	A description that makes reference to the following points: • calcium bromide and calcium iodide: orange–red / brick−red **(1)** • potassium sulfate: lilac **(1)**	Allow orange / red / yellow-red / yellow- orange Do not award brown, crimson, dark-red, carmine or ruby Do not award purple / mauve / violet / pink / blue-lilac	**(2)**

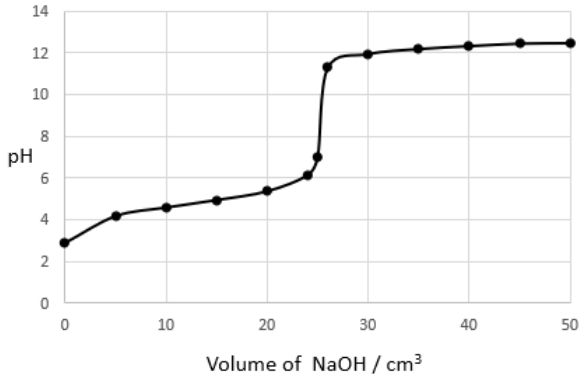
Question Number	Acceptable Answer	Additional Guidance	Mark
3(b)	A description that makes reference to the following points: • calcium bromide correct **(1)** • calcium iodide correct **(1)**	<table><tr><th>Solution</th><th>Formula of precipitate with silver nitrate</th><th>Colour of precipitate with silver nitrate</th><th>Observation with concentrated aqueous ammonia</th></tr><tr><td>calcium bromide(aq)</td><td>AgBr</td><td>cream / pale-yellow / off white</td><td>dissolves / disappears / Allow soluble</td></tr><tr><td>calcium iodide(aq)</td><td>AgI</td><td>yellow</td><td>does not dissolve / remains / no change Allow insoluble / no reaction</td></tr></table> If no other mark is awarded then award 1 mark for 4 correct boxes Ignore state symbols	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
3(c)	A description that makes reference to the following points: • add (dilute) HCl / (dilute) HNO_3 **and** (a solution of) barium chloride / $BaCl_2$ / barium nitrate / $Ba(NO_3)_2$ (to a sulfate solution) **(1)** • white precipitate / solid **(1)**	Allow concentrated HCl Do not award just 'acidified' Do not award incorrect formulae Do not award powder M2 depends on M1 or near miss (i.e acidified barium chloride) Allow ppt / ppte	**(2)**

Question Number	Answer	Mark
3(d)	**The only correct answer is A** (1.96 g) ***B*** *is not correct because it is the mass for 1 dm^3 of a solution of concentration 0.045 mol dm^{-3}* ***C*** *is not correct because it is the mass for 250 cm^3 of a solution of concentration 0.45 mol dm^{-3}* ***D*** *is not correct because this would be the mass for 4.0 dm^3 instead of 250 cm^3*	**(1)**

(Total for Question 3 = 10 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
4(a)	An answer that makes reference to the following point: • (a Brønsted-Lowry acid is a) proton donor / donator	Allow donates protons / H^+ (ions) / hydrogen ions	**(1)**

Question Number	Answer	Mark
4(b)	**The only correct answer is B** () ***A*** *is not correct because this is the titration curve of 0.100 mol dm^{-3} of a strong acid and 0.100 mol dm^{-3} of a strong base* ***C*** *is not correct because this is the titration curve of 0.100 mol dm^{-3} of a weak acid and 0.100 mol dm^{-3} of a weak base* ***D*** *is not correct because this is the titration curve of 0.100 mol dm^{-3} of a strong acid and 0.100 mol dm^{-3} of a weak base*	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
4(c)	An answer that makes reference to the following points: • hydrochloric acid is a strong acid **(1)** • sulfuric acid is diprotic / can donate two H^+ ions / protons **(1)** • the second ionisation of sulfuric acid is not complete / is suppressed by the first ionisation **(1)** • propanoic acid is a weak acid / partially dissociated **(1)**	Allow HCl is (almost) fully dissociated / ionised in solution Allow HCl $\longrightarrow$ $H^+ + Cl^-$ Do not award reversible arrow Ignore just H_2SO_4 is more strongly acidic than HCl Allow $H_2SO_4 \longrightarrow 2H^+ + SO_4^{2-}$ Ignore reversible arrow Allow this shown in an equation $HSO_4^- \rightleftharpoons H^+ + SO_4^{2-}$ Allow $CH_3CH_2COOH \rightleftharpoons CH_3CH_2COO^- + H^+$ Ignore just propanoic acid is weakly acidic / weakest acid	**(4)**

Question Number	Acceptable Answer	Additional Guidance	Mark
4(d)(i)	An answer that makes reference to the following point: • expression for K_a	$K_a = \frac{[H^+]\,[HCO_3^-]}{[H_2CO_3]}$ Ignore state symbols Allow H_3O^+ for H^+ Do not award round brackets.	**(1)**

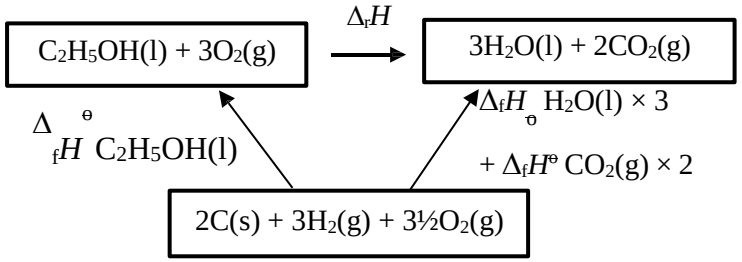
Question Number	Acceptable Answer		Additional Guidance	Mark
4(d)(ii)			Example of calculation	**(3)**
	• rearrangement or substitution of values into the equation	**(1)**	$[H^+] = \frac{K_a \times [H_2CO_3]}{[HCO_3^-]}$	
	• calculation of $[H^+]$	**(1)**	$[H^+] = \frac{(4.5 \times 10^{-7} \times 0.0020)}{0.024}$ $= 3.75 \times 10^{-8}$ (mol dm^{-3}) Allow TE from an incorrect expression in 4(c)(i) for 1 mark	
	• calculation of pH	**(1)**	$pH = -\log_{10} [H^+]$ $= -\log_{10} (3.75 \times 10^{-8}) = 7.426 / 7.43 / 7.4$ Standalone mark Allow TE on incorrect value Ignore SF except 1 SF	

Question Number	Acceptable Answer	Additional Guidance	Mark
4(e)(i)	An answer that makes reference to the following points: • the position of the first **and** second equilibria are shifted to the right (to use up the CO_2) **(1)** • (so the) concentration of H^+ / $[H^+]$ rises **(1)** **and** • (resulting in a) lower pH	Allow reference to each specific equilibrium and a comment about more of the relevant products being produced if no mention of a shift to the right. M2 dependent on M1 Ignore 'becomes more acidic' for lower pH	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
4(e)(ii)	An explanation that makes reference to the following points: • there is a (large) reservoir of HCO_3^- (and H_2CO_3) **(1)** • (when the H^+ ion concentration / $[H^+]$ increases) the H^+ ions / protons react with / the HCO_3^- to form more H_2CO_3 (so restoring the pH) **(1)**	Allow a large amount / high concentration Allow Equilibrium **2** shifts to the left hand side (so restoring the pH) Allow $H^+ + HCO_3^- \rightleftharpoons H_2CO_3$ Allow this equation with a forward arrow. Do not award the H^+ ions neutralise the HCO_3^- Ignore any mention of OH^- ions shifting equilibrium 2 to the left.	**(2)**

(Total for Question 4 = 14 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
5(a)	• calculation of enthalpy change for bonds breaking **(1)** • calculation of enthalpy change for bonds forming **(1)** • total enthalpy change with negative sign **(1)**	<u>Example of calculation</u> = (5 × 413) + 347 + 358 + 464 + (3 × 498) = (+) 4728 (kJ mol^{-1}) = (6 × 464) + (4 × 805) = (−) 6004 (kJ mol^{-1}) = (−6004 + 4728) = −1276 (kJ mol^{-1}) Correct answer with no working scores 3. Allow TE for M3 Allow SF apart from 1SF. (+)1276 scores 2	**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
5(b)(i)	An answer that makes reference to the following points: • correct species, balanced, with state symbols in the bottom box **(1)** • arrows in correct direction and labelled **(1)**	 Allow any suitable labels – e.g just $\Delta_f H$ / correct numbers left hand −277 and right hand −1646 or 3 × −286 and 2 × −394 Allow omission of state symbols on the arrows. Allow C(graphite) for C(s)	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
5(b)(ii)	• calculation of standard enthalpy of combustion of ethanol, $\Delta_c H^\ominus$ [C_2H_5OH]	<u>Example of calculation</u> $(\Delta_r H^\ominus [C_2H_5OH(l)] = (-286 \times 3) - (2 \times 394) + 277$ $= -1369$ (kJ mol^{-1}) Allow final answer rounded to −1370 as long as −1369 is seen and the sign on the final answer is correct. Correct answer scores 1 No TE on incorrect cycle	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
5(c)	An answer that makes reference to the following point: • (values are different because) mean bond enthalpies have been used (in the first calculation) (which are different from the actual values) **(1)** • (values are different) because the bond enthalpy values are given for substances in the gas state (and water and ethanol are liquids) **(1)**	Ignore references to standard conditions	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
5(d)	An answer that makes reference to the following points: • oxidation half−equation **(1)** • reduction half−equation **(1)**	$C_2H_5OH + 3H_2O \rightarrow 2CO_2 + 12e^{(-)} + 12H^+$ $4H^+ + 4e^{(-)} + O_2 \rightarrow 2H_2O$ Allow multiples Allow reversible arrows but equations must be written forwards Comment: Allow 1 mark if **both** equations correct but oxidation and reduction swapped Ignore state symbols even if incorrect	**(2)**

(**Total for Question 5 = 10 marks)**

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*6</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>

The following table shows how the marks should be awarded for structure and lines of reasoning.

<table>
<tr><th></th><th>Number of marks awarded for structure of answer and sustained line of reasoning</th></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>
</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, which 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).

In general it would be expected that 5 or 6 indicative points would get 2 reasoning marks, and 3 or 4 indicative points would get 1 mark for reasoning, and 0, 1 or 2 indicative points would score zero marks for reasoning.

If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).

Incorrect chemistry
Penalise the incorrect mention of a single d-orbital instead of d-orbitals or d-subshell once only in whole response
</td>
<td>(6)</td>
</tr>
</table>

	Indicative content: • **IP1 (electron configurations of Cu^{2+} and Fe^{2+})** correct electron configuration of both Cu^{2+} **and** Fe^{2+} ions • **IP2 (ligands and d orbitals)** ligand splits the (3) d-orbitals / (3) d-subshell splits (into higher and lower energy levels) • **IP3 (energy gap)** energy gap / ΔH / ΔE (between d-orbitals) is different in different (metal) ions / between Cu^{2+} and Fe^{2+} ions • **IP4 (electron promoted)** electron is promoted / excited / d−d transition **and** absorbing (visible) **light** energy / photons of different wavelength / colour • **IP5 (colour)** complementary colour seen / transmitted / reflected • **IP6 (zinc)** (zinc ions / Zn^{2+}) colourless because the (3)-d subshell / d-orbitals in Zn^{2+} are full / **and** Zn^{2+} is [Ar] $3d^{10}$ / $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $3d^{10}$ (and so d-d transitions cannot occur)	Cu^{2+} is [Ar] $3d^9$ / $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $3d^9$ Fe^{2+} is [Ar] $3d^6$ / $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $3d^6$ Allow the energy gap / energy difference determines the frequency of absorbed light Ignore the energy gap is dependent on the ligand. Allow energy levels for energy gap as long as it is clear they mean in the d-subshell / between the split d-orbitals Allow transition / promotion between energy levels Do not award transition / promotion between d-subshells Allow colour / light not absorbed seen Do not award reference to electrons returning to the ground state or emission of colour / light Ignore zinc (3)d subshell does not split Ignore zinc cannot bind ligands Allow no space for an electron to be promoted Do not award shell for subshell Penalise the incorrect mention of a single d-orbital instead of d-orbitals or d-subshell once only in whole response	

(Total for Question 6 = 6 marks)

Question Number	Answer	Mark
7(a)(i)	**The only correct answer is D** ($\frac{p(SO_3)}{p(SO_2)\,p(O_2)^{½}}$, $atm^{-½}$) ***A*** *is not correct because the expression is correct but the units are incorrect* ***B*** *is not correct because both the expression and the units are incorrect* ***C*** *is not correct because the expression is not correct*	**(1)**

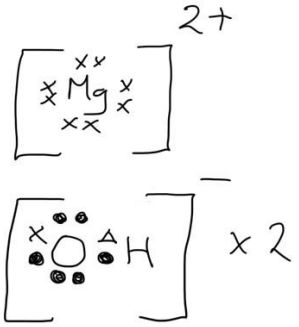
Question Number	Answer	Mark
7(a)(ii)	**The only correct answer is B** (temperature) ***A*** *is not correct because this would affect the rate of the reaction but not the value of* K_p ***C*** *is not correct because this would affect the rate of the reaction but not the value of* K_p ***D*** *is not correct because this would affect the rate of the forward reaction temporarily but not the value of* K_p	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
7(b)	An answer that makes reference to the following points: • $SO_2 + V_2O_5 \rightarrow SO_3 + V_2O_4$ **(1)** • $V_2O_4 + ½\ O_2 \rightarrow V_2O_5$ **(1)**	Allow multiples Allow reversible arrows Ignore state symbols even if incorrect Do not award equations with electrons Allow for 2 marks any balanced equations showing formation of a lower oxidation state oxide by reaction with SO_2 and a higher oxidation state by reaction with O_2 Example $2SO_2 + V_2O_5 \rightarrow 2SO_3 + V_2O_3$ $V_2O_3 + O_2 \rightarrow V_2O_5$ Allow use of $2VO_2$ instead of V_2O_4 in both equations	**(2)**

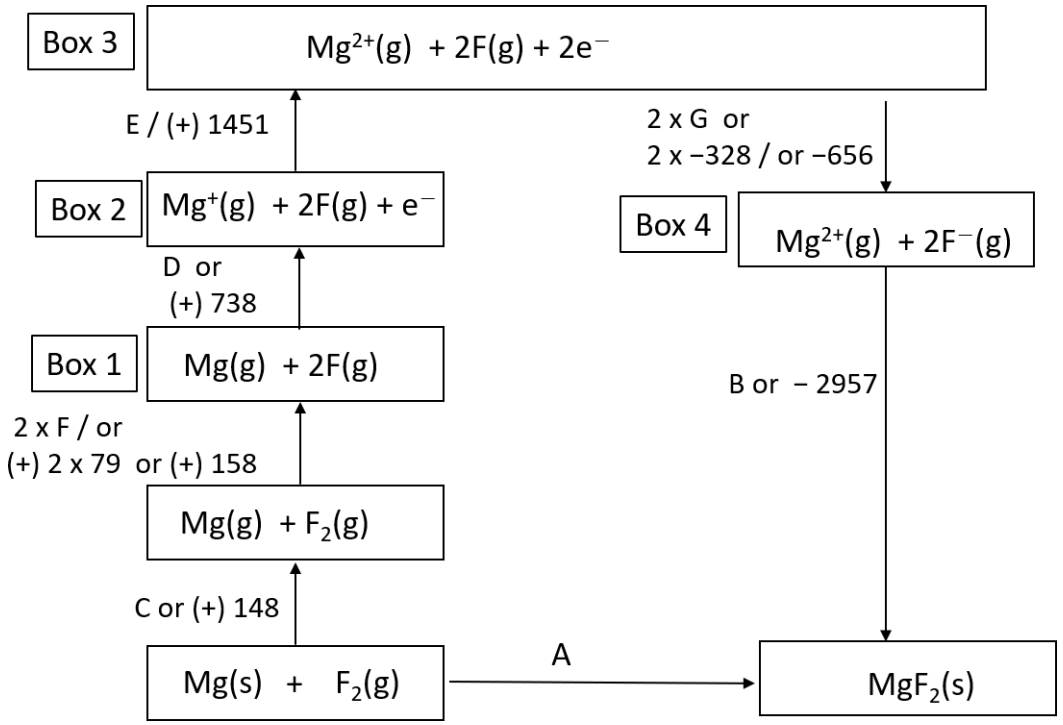
Question Number	Answer	Mark
7(c)	**The only correct answer is C (**VO_2^+ yellow +5) ***A*** *is not correct as although the colour is correct for* VO_2^+ *the oxidation number is incorrect* ***B*** *is not correct as although the oxidation number of vanadium is correct,* VO^{2+} *is blue* ***D*** *is not correct as* VO^{2+} *as although the colour of the solution is blue, the oxidation number of vanadium in* VO^{2+} *is +4*	**(1)**

Question Number	Answer	Mark
7(d)	**The only correct answer is A** (+1.76 V) ***B*** *is not correct because the* $E^{\ominus}$ *values have been added* ***C*** *is not correct because the* $E^{\ominus}$ *values have been added and the sign reversed* ***D*** *is not correct because this is the value for the reverse reaction*	**(1)**

(Total for Question 7 = 6 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
8(a)	An explanation that makes reference to the following points: • magnesium ion with correct structure and charge **(1)** • structure of two hydroxide ions with correct charge **(1)**	 Allow Mg^{2+} with no electrons in the outer shell Ignore inner shell electrons Allow circle(s) of electron shells to be shown Allow square brackets missing Penalise incorrect symbols once	**(2)**

Question Number	Answer	Mark
8(b)	**The only correct answer is B** (The enthalpy change when 1 mol of an ionic substance dissolves in water to give an infinitely dilute solution.) ***A*** *is not correct as the mention of gaseous ions is incorrect* ***C*** *is not correct as the mention of gaseous ions is incorrect and the concentration is incorrect* ***D*** *is not correct as the concentration is incorrect*	**(1)**

Question Number	Answer and Additional Guidance	Mark
8(c)(i)	 • correct letters B, D, E, F, G or correct values corresponding to their cycle, G and B must be on the correct boxes **(1)** • multiplying F and G by 2 (must be seen on the cycle for this mark) **(1)** • correct formulae in every box **(1)** • state symbols and electrons (charge does not need to be shown on electrons) **(1)** Accept order of alternative order of boxes 2 – 3 – 1 with accompanying letters etc	**(4)**

Question Number	Acceptable Answer	Additional Guidance	Mark
8(c)(ii)	• correct answer	<u>Example of calculation</u> $(148 + (2 \times 79) + 738 + 1451 + (-328 \times 2) + (-2957))$ $= -1118$ (kJ mol^{-1}) Comment if -1118 seen then award the mark no matter what their cycle indicates No TE on incorrect values mis-transcribed on their cycle Allow TE if matches cycle -790 scores 1 (electron affinity not doubled) -869 scores 1 (both values not doubled) -1197 scores 1 (atomisation not doubled)	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
8(c)(iii)	An explanation that makes reference to the following points: • (theoretical and experimental values of MgF_2 are close / similar as) MgF_2 is (nearly) 100% **ionic** **(1)** • (theoretical and experimental values of MgI_2 are different as) MgI_2 has some **covalent** character / more **covalent** character than MgF_2 **(1)** • I^- / iodide ions are more polarisable (than F^- (ions)) / highly polarisable / because the I^- ions are larger / have a larger radius **(1)** • values for MgF_2 are more negative / more exothermic than for MgI_2 as the (ionic) bonding is stronger in MgF_2 (because the F^- ion is smaller than the I^- ion) **(1)**	Allow reverse argument throughout Allow MgF_2 is more **ionic** than MgI_2 Allow iodine ions / fluorine ions Allow I^- can be distorted more Allow bond between Mg and I more polarised as long as ions mentioned in response. Do not award species other than ions (e.g. atom, molecule) Do not award atomic radius is larger Allow 'higher' for 'more negative'	**(4)**

(Total for Question 8 = 12 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
9(a)	• calculation of ΔS_{system} **(1)** • calculation of $\Delta G^{\ominus}$ with appropriate units **(1)** • reason why not feasible **(1)**	<u>Example of calculation</u> = (135 + 213.6 + 69.9) – (2 × 101.7) = (+) 215.1 (J K^{-1} mol^{-1}) / (+) 0.2151 (kJ K^{-1} mol^{-1}) ($\Delta G = \Delta H - T\,\Delta S_{system}$) = (+ 91.6 × 1000) – (298 × 215.1) = (+) 27500 J mol^{-1} / 27500.2 J mol^{-1} / (+) 27.500 kJ mol^{-1} / 27.5002 kJ mol^{-1} TE on answer to M1 Ignore SF except 1SF ΔG positive / $\geq$ / >0 so not feasible (standalone mark)	**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
9(b)	• rearrangement of ΔG expression and calculation of feasible temperature **(1)** • conversion to degrees Celsius **(1)**	Example of calculation $T = \Delta H / \Delta S_{system}$ T = 91.6 / 0. 2151 = 425.8 K 425.8 K – 273 = 152.8/ 153 (^{o}C) Allow 160 (^{o}C) Do not award 150 (^{o}C) if rounded down Do not award a negative answer for the temperature. Credit can be given for working that uses $\Delta S_{tot} = 0$ $\Delta S_{tot} = 0 = 215.1 + (-91600 / T)$ T = −91600 / −215.1 = 425.8 **(1)** Conversion to ^{o}C = 425.8 −273 = 152.8 ^{o}C **(1)** TE from answer to 9(a) Ignore SF except 1SF	**(2)**

(Total for Question 9 = 5 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
10(a)	An answer that makes reference to the following points: • (dissolve) in deionised water (in a beaker) **(1)** **and** transfer to a volumetric flask • (wash the beaker and) transfer the washings **(1)** • make up to the mark and invert / mix (thoroughly) **(1)**	Steps have to be in a logical order. Allow distilled for deionised Allow direct transfer of the solid to the volumetric flask Ignore use of pestle and mortar Comment allow this mark as long as deionised /distilled water is seen in the response Allow any indication of mixing eg shaking / stirring / etc	**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
10(b)(i)	An answer that makes reference to the following point: • $IO_3^- + \mathbf{5}I^- + \mathbf{6}H^+ \rightarrow + 3I_2 + \mathbf{3H_2O}$		**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
10(b)(ii)	• moles potassium iodate **(1)** • moles iodine generated **(1)**	<u>Example of calculation</u> $0.01 \times 0.025 = 2.5 \times 10^{-4}$ $3 \times 2.5 \times 10^{-4} = 7.5 \times 10^{-4}$ Allow calculation shown in one step. No TE on incorrect values Allow answers not in standard form	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
10(c)(i)	An answer that makes reference to the following points: • starch **(1)** • blue-black to colourless **(1)**	Allow blue or black to colourless Do not award light blue M2 depends on M1	**(2)**

Question Number	Acceptable Answer		Additional Guidance	Mark
10(c)(ii)			Example of calculation	**(6)**
	• moles thiosulfate used in titration	**(1)**	= $14.40 \times 0.100 \div 1000 = 1.44 \times 10^{-3}$ / 0.00144	
	• moles unreacted iodine in flask	**(1)**	= $\frac{1.44 \times 10^{-3}}{2} = 7.2 \times 10^{-4}$ / 0.00072	
	• moles of iodine that reacted with 10.0 cm^3 vitamin C tablet solution **and** (therefore) moles of ascorbic acid in 10.0 cm^3 vitamin C tablet solution	**(1)**	= $7.5 \times 10^{-4} - 7.2 \times 10^{-4}$ = 3.00×10^{-5} / 0.00003	
	• moles of ascorbic acid in 250 cm^3 solution (1 tablet)	**(1)**	= $3.00 \times 10^{-5} \times 25 = 7.5 \times 10^{-4}$ / 0.00075	
	• mass of ascorbic acid in 1 tablet	**(1)**	= $7.5 \times 10^{-4} \times 176 = 0.132$ (g)	
	• expected mass of ascorbic acid in 1 tablet **and** the label is wrong (as there is too little vitamin C in each tablet) **or** percentage of ascorbic acid in 1 tablet **and** the label is wrong (as there is too little vitamin C in each tablet)	**(1)**	Expected mass of ascorbic acid in tablet = 6 / 100 × 2.5 = 0.15 g (which is greater than 0.132 g) Percentage = 0.132 ÷ 2.50 × 100 = 5.28% Calculations for MP4 and MP5 can be done in either order Correct answer without working scores 6 TE at all stages	

(Total for Question 10 = 14 marks)
TOTAL FOR PAPER = 90 MARKS

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