Mark Scheme (Results)

October 2020

Pearson Edexcel GCE
In Chemistry (9CH0)
Paper 1: 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 <u>meaning</u> 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.

Question Number	Answer	Mark
1(a)	**The only correct answer is B** ($Al^{2+}(g) \rightarrow Al^{3+}(g) + e^-$) **A** *is not correct because it is the equation for the first three ionisation energies* **C** *is not correct because an ion is gaining electrons* **D** *is not correct because an ion is gaining an electron*	**(1)**

Question Number	Answer	Mark
1(b)	**The only correct answer is C** (Y) **A** *is not correct because there is a steady increase in ionisation energies* **B** *is not correct because there is a steady increase in ionisation energies* **D** *is not correct because there is a large increase after the first ionisation energy, so Z is a Group 1 element*	**(1)**

Question Number	Answer	Mark
1(c)	**The only correct answer is C** (c) **A** *is not correct because it is carbon* **B** *is not correct because it is nitrogen* **D** *is not correct because it is aluminium*	**(1)**

Question Number	Answer	Additional Guidance	Mark
1(d)	• N^{3-} / O^{2-} / F^{-} / Na^{+} / Al^{3+}	Do not award Ne, C^{4-}, Si^{4+}	**(1)**

Question Number	Answer	Additional guidance	Mark
1(e)	A discussion that makes reference to the following points: • both elements / atoms have the last added electron in the d-subshell / d orbital (so are d-block elements) **(1)** • but neither forms a (stable) ion with an incomplete d-subshell / d orbital (so are not transition metals) **(1)** • Zn^{2+} is $1s^22s^22p^63s^23p^63d^{10}$ (so d subshell is full) **(1)** • Sc^{3+} is $1s^22s^22p^63s^23p^6$ (so d subshell is empty) **(1)**	Do not award just 'contains d electrons' Allow 'transition elements form a (stable) ion with an incomplete d-subshell / d orbital' Allow $[Ar]3d^{10}$ Allow [Ar]	**(4)**

(Total Question 1 = 8 marks)

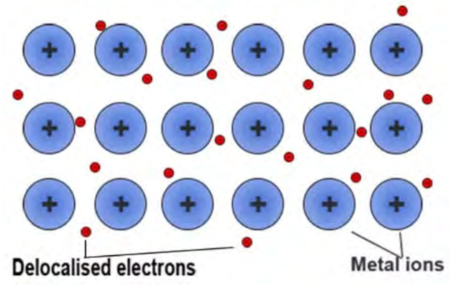
Question Number	Answer	Mark
2(a)	**The only correct answer is A** ($CH_3COOH > CH_2ClCOOH > HCl$) *B is incorrect because HCl is the only strong acid, so would have the lowest pH* *C is incorrect because $CH_2ClCOOH$ is stronger than CH_3COOH as the Cl atom stabilises the anion* *D is incorrect because the stronger the acid the lower the pH, hence these are in reverse order*	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(b)	• calculation of $[H^+]$ **(1)** • use of K_a expression to calculate K_a **(1)** • calculation of pK_a **(1)**	Example of calculation $[H^+] = 10^{-2.20} = 6.3096 \times 10^{-3}$ ($mol\ dm^{-3}$) $K_a = (6.3096 \times 10^{-3})^2 / 0.240$ $= 1.6588 \times 10^{-4}$ $pK_a = -\log [1.6588 \times 10^{-4}] = 3.7802$ ignore SF except 1SF ignore units allow TE throughout correct answer with no working scores 3	**(3)**

Question Number	**Answer**	**Mark**
2(c)	**The only correct answer is B** (NaOH(aq) and excess CH_3COOH(aq)) ***A*** *is incorrect because the solutions would not form a buffer* ***C*** *is incorrect because the solutions would not form a buffer* ***D*** *is incorrect because the solutions would not form a buffer*	**(1)**

Question Number	**Answer**	**Mark**
2(d)	**The only correct answer is D** (none of these three indicators) ***A*** *is incorrect because both acid and base are weak so pH range at equivalence is too narrow for bromothymol blue to change colour* ***B*** *is incorrect because both acid and base are weak so pH range at equivalence is too narrow for methyl orange to change colour* ***C*** *is incorrect because both acid and base are weak so pH range at equivalence is too narrow for phenolphthalein to change colour*	**(1)**

(Total Question 2 = 6 marks)

Question Number	Answer	Additional Guidance	Mark
3(a)	An explanation that makes reference to the following points (Structure consisting of) • lattice of positive ions / regular arrangement of positive ions **(1)** • (in sea of) delocalised electrons **(1)** • strong forces of attraction between ions and delocalised electrons (so high melting temperature) **(1)** • so lots of (heat) energy needed to break attraction between ions and delocalised electrons / metallic bonds **(1)**	M1 and M2 can be scored by use of a labelled diagram, but if both given both must be correct For example  Allow charge on ion of 2+ or 3+ Diagram should show at least 4 ions (for M1) a number of electrons roughly consistent with charge on ions and random (for M2) The attraction between ions and delocalised electrons only needs to be mentioned once in M3 and M4 Allow 'lots of energy needed to separate the ions'	**(4)**

Question Number	Answer	Additional Guidance	Mark
3(b)(i)	• octahedral	Allow octahedron / octahedral Ignore diagrams Do not award octagonal	**(1)**

Question Number	Answer	Additional Guidance	Mark
3(b)(ii)	An explanation that makes reference to the following points • (ligand / water molecule causes) d orbital**s** to split (into 2 energy levels) **(1)** • light/energy (in the visible region) absorbed to promote electrons (to higher d orbitals) **(1)** • the remaining light / unabsorbed light / complementary colour / green light is transmitted **(1)**	Allow d subshell for d orbitals Do not award d orbital splits Allow (some light) energy is absorbed when d-d electron transitions occur Do not award 'emitted' or transmission linked to electrons returning to ground state Allow reflected / emerged	**(3)**

Question Number	Answer	Additional Guidance	Mark
3(c)	An answer that makes reference to the following points: • (the equilibrium constant is large) so the equilibrium lies well / far to the right hand side / $[Cr(EDTA)]^-$ is more stable **(1)** • as ΔS_{system} is positive / increases entropy (of the system) **(1)** • as 2 mol of reactants form 7 mol of products **(1)**	Allow forward reaction is very feasible / spontaneous / goes (virtually) to completion Allow an increase in the number of moles / particles / molecules if number of moles is given, they must be correct i.e. do not award 2 moles to 6 moles Do not award just '2 molecules form 7 molecules' Do not award M3 if M2 states 'entropy decreases'	**(3)**

Question Number	Answer	Additional guidance	Mark
3(d)(i)	• calculation of moles of VCl_2(aq) **(1)** • calculation of moles of Cl_2(g) **(1)** • deduction of whole number ratio of $V^{2+} : Cl_2$ **(1)** • deduction of electrons lost per vanadium ion **(1)** • deduction of final oxidation number of V **(1)**	<u>Example of calculation</u> (40/1000) x 0.100 = 4 x 10^{-3} / 0.004 (mol) (144/24000) = 6 x 10^{-3} / 0.006 (mol) $2V^{2+} : 3Cl_2$ allow $V^{2+} : 1.5Cl_2$ 6 electrons lost by $2V^{2+}$, so 3 lost per V^{2+}, (+)5 Allow TE throughout Correct answer with no working scores M5 only	**(5)**

Question Number	Answer	Additional Guidance	Mark
3(d)(ii)	• purple / lilac / violet **(1)** • to yellow (solution) **(1)**	Ignore references to blue / green / turquoise or similar, as intermediate colours, regardless of order If no final oxidation state given in (d)(i) do not award M2 Allow lavender / mauve for M1 Mark consequentially from (d)(i) Do not award colourless Use list principle for additional inappropriate intermediate colours e.g. red / pink For consequential marking from (d)(i) V(IV) – blue ; V(III) – green If both colours are given but the wrong way round, allow 1 mark out of 2	**(2)**

(Total Question 3 = 18 marks)

Question Number	Answer	Mark
4(a)	**The only correct answer is C** (magnesium sulfate) ***A*** *is incorrect because Group 2 sulfates decrease in solubility down Group 2* ***B*** *is incorrect because Group 2 sulfates decrease in solubility down Group 2* ***D*** *is incorrect because Group 2 sulfates decrease in solubility down Group 2*	**(1)**

Question Number	Answer	Mark
4(b)	**The only correct answer is B** (–157) ***A*** *is incorrect because this is the value if the cycle is used in the opposite direction* ***C*** *is incorrect because this is the value if the hydration enthalpy for the chloride ion is not multiplied by 2* ***D*** *is incorrect because this is the value if the cycle is used in the opposite direction and the hydration enthalpy for the chloride ion is not multiplied by 2*	**(1)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>*4(c)</td><td>
This question assesses the 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><td>Number of indicative marking points seen in answer</td><td>Number of marks awarded for indicative marking points</td></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><td></td><td>Number of marks awarded for structure of answer and sustained lines of reasoning</td></tr>
<tr><td>Answer shows a coherent 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, a response with four 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 were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and zero marks for linkages).

In general, an answer with 5 or 6 IPs would score 2 reasoning marks, 3 or 4 IPs would score 1 reasoning mark, 0, 1 or 2 IPs would score 0 reasoning marks.

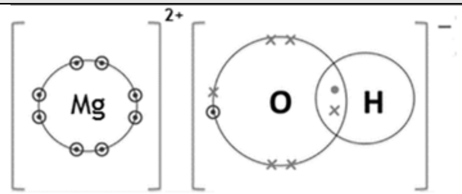
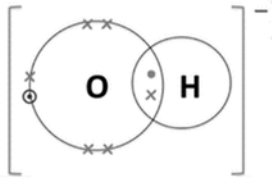
Reasoning marks may be reduced for extra incorrect chemistry.
</td><td>(6)</td></tr>
</table>

	Indicative content • 2-methylpentane is insoluble in water as it cannot hydrogen bond to water (as none of the hydrogen atoms are electropositive) • 2-methylpentane is soluble in hexane as London forces in both compounds (are similar in strength / size) • so (resultant) forces in mixture are similar in magnitude to those in each liquid • potassium bromide is soluble in water as its ions are hydrated when dissolved • the enthalpy change of hydration is greater than / close to / compensates for the energy needed to break apart the lattice • potassium bromide is insoluble in hexane as any (London) forces that form between it and hexane would be smaller in magnitude than the forces between the ions	If there is no specific reference to types of intermolecular forces / interaction in IPs 1 and 2 then allow 1 IP for idea of ‘like dissolves like’ e.g. 2-methylpentane dissolves in hexane as they are both non-polar / does not dissolve in water as water is polar scores 1IP if both IP1 and IP2 not awarded Allow van der Waals / dispersion forces / instantaneous dipole-induced dipole Allow both form only London forces Ignore references to entropy Do not award if water is shown as split into ions	

(Total Question 4 = 8 marks)

Question Number	Answer	Additional Guidance	Mark
5(a)(i)	Any two observations from • solid dissolves / melts **(1)** • condensation on sides of test tube **(1)** • brown gas/ brown fumes/ brown $NO_2(g)$ produced **(1)** • white solid / powder forms **(1)**	Do not award magnesium dissolved / just 'solid disappears' Allow 'steam given off' Ignore NO_2 / O_2 / gas given off/ bubbles/ effervescence / gas relights a glowing splint Allow red-brown Ignore 'precipitate' Ignore 'magnesium oxide forms' Do not award 'Mg^{2+} forms'	**(2)**

Question Number	Answer	Additional Guidance	Mark
5(a)(ii)	An answer that makes reference to the following points: • Nitrates increase in stability down Group 2 as ionic radius increases (as you go down group) **(1)** • so polarising ability of metal (ion) decreases / distorts (the electron cloud of) the anion less **(1)** • weakening of N-O bonds (in nitrate ion) is less **(1)**	Allow charge density decreases as you go down Group 2 Do not award **just** 'atomic radius increases' There has to be a mention of ions somewhere in M1 or M2 Allow reverse argument	**(3)**

Question Number	Answer	Additional Guidance	Mark
5(b)(i)	• magnesium ion (1) • hydroxide ion (1)	 Allow all dots or all crosses Allow M1 for magnesium ion outer shell shown with no electrons Allow M2 even if only 1 hydroxide ion is shown Ignore inner shells Ignore absence of square brackets and circles Ignore any indication of 2 hydroxide ions e.g. 1 hydroxide ion with '2' preceding it Penalise missing charges once only	**(2)**

Question Number	Answer	Additional Guidance	Mark
5(b)(ii)		<u>Example of calculation</u>	**(5)**
	• calculation of moles of $Mg(OH)_2$ **(1)**	$0.174 \div 58.3 = 2.98456 \times 10^{-3}$ (mol)	
	• calculation of mass of $Mg(NO_3)_2$ **(1)**	$2.98456 \times 10^{-3} \times 148.3 = 0.44261$ (g)	
	• calculation of mass of H_2O **(1)**	$0.765 - 0.44261 = 0.32239$ (g)	
	• calculation of moles of H_2O **(1)**	$0.32239 \div 18 = 0.017911$ (mol)	
	• deduction of $Mg(NO_3)_2$: H_2O ratio (and hence formula) **(1)**	$0.017911 \div 2.98456 \times 10^{-3} = 6.0011$ 1:6, (so $Mg(NO_3)_2.6H_2O$)	
	OR		
	• Calculation of moles of $Mg(OH)_2$ **(1)**	$0.174 \div 58.3 = 2.98456 \times 10^{-3}$ (mol)	
	• deduction of moles of $Mg(NO_3)_2.xH_2O$ **(1)**	1:1 so = 2.98456×10^{-3} (mol)	
	• expression for / calculation of molar mass of $Mg(NO_3)_2.xH_2O$ **(1)**	$148.3 + 18x$ / $0.765 \div 2.98456 \times 10^{-3} = 256.3$	
	• expression for moles of $Mg(NO_3)_2.xH_2O$ in terms of mass and molar mass / calculation mass of water in 1 mole **(1)**	$0.765 \div (148.3 + 18x) = 2.98456 \times 10^{-3}$ (mol) / $256.3 - 148.3 = 108$	
	• calculation of x (and hence formula) **(1)**	$0.32239 = 0.0537x$, so $x = 0.32239 \div 0.0537 = 6.0035$ / $108 \div 18$ so $x = 6$; (so $Mg(NO_3)_2.6H_2O$) Correct answer with no working scores M5 only. Ignore SF from M1 to M4, allow TE throughout	

(Total Question 5 = 12 marks)

Question Number	Answer	Additional guidance	Mark
6(a)(i)	An explanation that makes reference to the following points • C=C bond is weaker than 2 x C-C bond **(1)** • as it consists of a pi and a sigma bond (rather than 2 sigma bonds) **(1)**	Ignore pi bond formed by sideways / less effective orbital overlap	**(2)**

Question number	Answer	Additional guidance	Mark
6(a)(ii)	• calculation of energy required to break reactant bonds **(1)** • calculation of energy release when product bonds form **(1)** • calculation of enthalpy change **(1)**	<u>Example of calculation:</u> 5(C-H) + (C=C)+(C- C)+(C-O)+(O-H)+4(O=O) 5(413) + (612) + (347) + (358) + (464) + (4x498) = 5838 (kJ mol^{-1}) 6(C=O) + 6(O-H) (6x805) + (6x464) = 7614 (kJ mol^{-1}) 5838 – 7614 = –1776 (kJ mol^{-1}) Ignore SF except 1 SF Allow TE from M1 and M2 Correct answer no working scores 3	**(3)**

Question Number	Answer	Additional Guidance	Mark
6(a)(iii)	An explanation that makes reference to one of the following points EITHER • $\Delta S_{\mathrm{total}}$ is always positive (1) **(1)** • As both $\Delta S_{\mathrm{surroundings}}$ and $\Delta S_{\mathrm{system}}$ are positive **(1)** • OR • ΔG is always negative **(1)** • as ΔH is negative and $\Delta S_{\mathrm{(system)}}$ is positive **(1)**	If no marking points awarded allow 1 mark for idea that $\Delta S_{\mathrm{system}}$ / $\Delta S_{\mathrm{surroundings}}$ / entropy increases with correct explanation	**(2)**

Question Number	Answer	Additional Guidance	Mark
6(b)	• expression for ΔS_{system} **(1)** • calculation of ΔS_{system} **(1)** • expression for $\Delta S_{surroundings}$ **(1)** • calculation of $\Delta S_{surroundings}$ **(1)** • calculation of ΔS_{total}, correct units and comment on feasibility **(1)**	<u>Example of calculation</u> ΔS_{system} = [(6x205)+(219.5)+(160.7)] − [(4x213.6)+(5x69.9) = 1610.2 − 1203.9 = (+) 406.3 (J K^{-1} mol^{-1}) $\Delta S_{surroundings}$ = −$\Delta H/T$ = − 2778 x 10^{3}/298 = −9322.14765 (J K^{-1} mol^{-1}) ΔS_{total} = 406.3 − 9322.14765 = − 8915.85 J K^{-1} mol^{-1}, (negative) so not feasible Ignore SF except 1 SF. Allow TE and KJ throughout	**(5)**

(Total for Question 6 = 12 marks)

Question Number	Answer	Additional Guidance	Mark
7(a)(i)	• $K_c = \frac{[CH_3COOCH_2CH_3(l)][H_2O(l)]}{[CH_3COOH(l)][CH_3CH_2OH(l)]}$	Ignore omission of state symbols Do not award round brackets	(1)

Question Number	Answer	Additional Guidance	**Mark**
7(a)(ii)	• expression for equilibrium amounts in terms of x **(1)** • use equilibrium amounts in K_c expression and rearrangement to find amount of product / express as correct quadratic expression **(1)** • calculation of amount of product **(1)**	<u>Example of calculation</u> Amounts CH_3CH_2OH = 1.2 – x; CH_3COOH = 1.2 – x; $CH_3COOCH_2CH_3$ = x; H_2O = x $K_c = \frac{(x \circ vol)^2}{[(1.2-x) \circ vol]^2}$ $K_c = (x^2 \circ vol^2) \circ ((1.2-x)^2 \circ vol^2)$ $K_c = x^2 \circ (1.2-x)^2$ so $x^2 = K_c \times (1.2-x)^2$ $x = \sqrt{K_c} \times (1.2-x)$ x=0.63498○1.52915; x= 0.41525 = 0.42 (So amounts of each product = 0.42 (mol)) Allow use of quadratic equation for M2 Allow M2 for expression without inclusion of volume Correct answer with no working scores 3 marks Ignore SF except 1 SF Ignore negative amounts Allow alternative methods Allow TE throughout (a)(ii) for use of x / $(1.2-x)^2$ in K_c expression	**(3)**

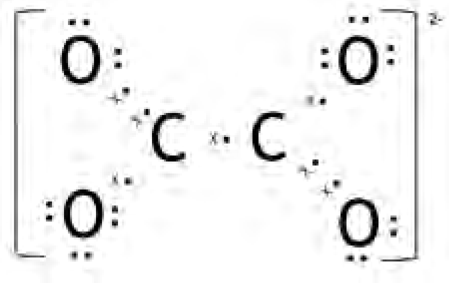
Question Number	Answer	Mark
7(b)(i)	**The only correct answer is C** (120° and 109.5°) ***A*** *is incorrect because both angles are incorrect* ***B*** *is incorrect because 90° is incorrect* ***D*** *is incorrect because 109.5° is incorrect for the left hand O−C−H angle*	**(1)**

Question Number	Answer	Mark
7(b)(ii)	**The only correct answer is D** (atm^{-1}) ***A*** *is incorrect because it is the inverse of the units for* K_C ***B*** *is incorrect because it is the units for* K_C ***C*** *is incorrect because it is the inverse of the units for* K_p	**(1)**

(Total Question 7 = 8 marks)

Question Number	Answer	Additional Guidance	Mark
7(b)(iii)	An explanation that makes reference to the following points • K_p will remain unchanged **(1)** • equilibrium moves to right-hand side (to keep K_p constant) / only temperature affects K_p **(1)**	Allow answers in terms of quotient Do not award M2 if K_p is described as changing Ignore comments related to rate	**(2)**

Question Number	Answer	Additional Guidance	Mark
8(a)	• colourless to (permanent pale/light) pink	Do not award purple for pink	**(1)**

Question Number	Answer	Additional Guidance	Mark
8(b)(i)	• double C=O bond on left and right hand side **(1)** • rest of diagram **(1)**		**(2)**

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	• (+) 3	Allow 3+ / +III / III+ / III / three Ignore working out Do not award ± 3	**(1)**

Question Number	Answer	Additional Guidance	Mark
8(c)	to provide the hydrogen ions (needed as a reactant in the balanced equation) / to prevent formation of MnO_2 / to prevent (brown) precipitate forming	Allow reaction needs acidic conditions Do not award 'acts as a catalyst' / just 'ensures reaction go to completion'	**(1)**

Question Number	Answer	Additional Guidance	Mark
8(d)	• both platinum symbols and salt bridge **(1)** • rest of diagram **(1)**	$Pt(s) \mid C_2O_4^{2-}(aq)\,,\, 2CO_2(g) \;\vdots\vdots\; [MnO_4^-(aq) + 8H^+(aq)],\, [Mn^{2+}(aq) + 4H_2O(l)] \mid Pt(s)$ Allow solid lines for salt bridge Allow half cells shown correctly on opposite side Ignore omission of square brackets / state symbols if neither marked scored allow 1 mark for all four ‘redox’ species in ROOR order, separated by commas or dashed lines, but not solid lines	**(2)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>8(e)(i)</td><td>• titres calculated and both ticks correct (1)

• mean calculated (1)</td><td>
<table>
<tr><td>Run</td><td>Trial</td><td>One</td><td>Two</td><td>Three</td></tr>
<tr><td>Final volume / cm^3</td><td>17.50</td><td>34.10</td><td>17.20</td><td>34.10</td></tr>
<tr><td>Initial volume /cm^3</td><td>0.00</td><td>17.30</td><td>0.00</td><td>17.20</td></tr>
<tr><td>Titre / cm^3</td><td>17.50</td><td>16.80</td><td>17.20</td><td>16.90</td></tr>
<tr><td>Concordant titres (✓)</td><td></td><td>✓</td><td></td><td>✓</td></tr>
<tr><td>Mean titre /cm^3</td><td colspan="4">16.85</td></tr>
</table>
Both titres to 2 dp
mean = (16.90+16.80)÷2 = 16.85 (cm^3)
allow TE for M2 for mean of One, Two and Three = 16.97 (cm^3)</td><td>(2)</td></tr>
</table>

Question Number	Answer	Additional Guidance	Mark
8(e)(ii)	• calculation of moles of $Na_2C_2O_4$(aq) **(1)** • calculation of moles of $KMnO_4$ in titre **(1)** • calculation of moles of $KMnO_4$ in 100 cm^3 **(1)** • calculation of M_r for $KMnO_4$ **(1)** • calculation of mass of 1 tablet in mg to 2 or 3SF **(1)**	<u>Example of calculation</u> (25.0÷1000) x 0.200 = 0.005 / 5.00×10^{-3} (mol) 5.00×10^{-3} x 2÷5 = 0.002 / 2.00×10^{-3} (mol) 2.00×10^{-3} x (100÷16.85) = 0.011869 (mol) 158 0.011869 x 158 = 1.8754 g (1.8754÷5) x 1000 = 375.07 mg = 380 / 375 (mg) Correct answer with or without working scores 5 marks 0.38 g scores 4 marks (M5 not awarded) TE at each stage and on mean titre 379 mg from 0.012 scores (5)	**(5)**

Question Number	Answer	Additional Guidance	Mark
8(e)(iii)	An explanation that makes reference to the following points • (reaction is slow initially) as MnO_4^- and $C_2O_4^{2-}$ are (both) negative (ions) so will repel (each other) **(1)** • when (sufficient) Mn^{2+} ions form they (auto) catalyse the reaction **(1)** • Mn^{2+} ions will reduce MnO_4^- ions (as $E^\ominus$ is more negative) forming Mn^{3+} ions OR $MnO_4^- + 8H^+ + 4Mn^{2+} \rightarrow 5Mn^{3+} + 4H_2O$ ($E^\ominus = +0.02V$) **(1)** • Mn^{3+} ions then oxidise $C_2O_4^{2-}$ ions (reforming Mn^{2+}) (as $E^\ominus$ is more positive) OR $C_2O_4^{2-} + 2Mn^{3+} \rightarrow 2Mn^{2+} + 2CO_2$ ($E^\ominus = +0.85V$) **(1)**	Allow 'heat is required to overcome high activation energy when catalyst is absent' Allow Mn^{2+} ions will react with MnO_4^- ions as $E^\ominus$ is more negative Allow Mn^{3+} ions then react with $C_2O_4^{2-}$ ions (reforming Mn^{2+}) as $E^\ominus$ is more positive May be shown in equations and / or by calculating $E^\ominus$	**(4)**

(Total Question 8 = 18 marks)

TOTAL FOR PAPER = 90 MARKS