Pearson Edexcel

Mark Scheme (Results)

Summer 2025

Pearson Edexcel GCE A Level
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.

Question Number	Answer		Additional Guidance	Mark
1(a)	An answer that makes reference to the following points: • (relative isotopic mass) is the mass of an atom (of the isotope / element) • relative to 1/12th (the mass of an atom) of carbon − 12	 **(1)** **(1)**	 Allow mass of an isotope of an atom Do not award any reference to average / mean / weighted or moles in M1 or M2, but penalise only once if in both Allow for two marks $\dfrac{\text{Mass of one atom of an isotope} \times 12}{\text{Mass of one atom of carbon-12}}$ COMMENT M1 can be awarded if atom mentioned somewhere in response	**(2)**

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

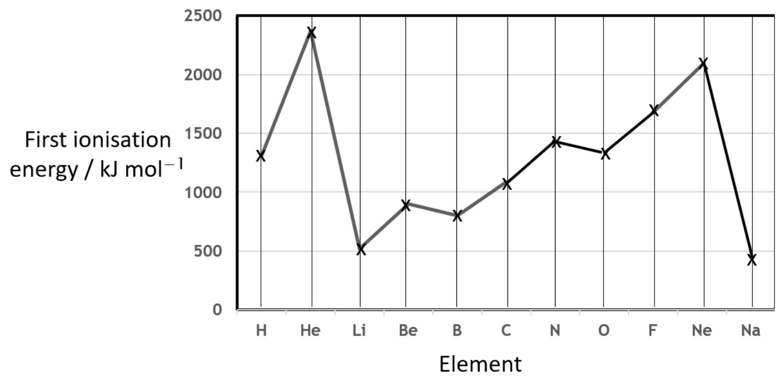
• all isotopes have 18 protons (and 18 electrons) (1)

• the isotopes have different numbers of neutrons, 18, 20 and 22 (1)</td><td>Do not award incorrect number of electrons

<table><tr><th>Isotope</th><th>Protons</th><th>Neutrons</th></tr><tr><td>^{36}Ar</td><td>18</td><td>18</td></tr><tr><td>^{38}Ar</td><td>18</td><td>20</td></tr><tr><td>^{40}Ar</td><td>18</td><td>22</td></tr></table>
If no other mark awarded allow isotopes have the same number of protons but a different number of neutrons for 1 mark
Ignore same atomic number and different mass number</td><td>(2)</td></tr>
</table>

Question Number	Answer	Additional Guidance	Mark
1(c)	• correct expression for calculation of A_r **(1)** • value given to 2 dp **(1)**	<u>Example of calculation</u> $A_r = \frac{((35.97 \times 0.337) + (37.96 \times 0.0630) + (39.96 \times 99.6))}{100}$ (= 39.945) = 39.95 TE on correct calculation from incorrect transposed numbers or use of whole numbers for relative isotopic mass Ignore g mol^{-1} but penalise other units Correct answer with no working scores 2	**(2)**

(Total for Question 1 = 6 marks)

Question Number	Answer	Additional Guidance	Mark
2(a)	An answer that makes reference to the following points: • nitrogen above both carbon and oxygen and below fluorine **(1)** • oxygen below both nitrogen and fluorine and above carbon **(1)** • sodium below lithium **(1)**	<u>Example of graph</u>  Accept just points Penalise plots on x-axis between elements once only	**(3)**

Question Number	Answer		Additional Guidance	Mark
2(b)	An explanation that makes reference to the following points: (the value for) beryllium is higher than lithium • as beryllium has one more proton / a higher nuclear charge • shielding is the same / similar in beryllium and lithium **or** electron repulsion is the same / similar in beryllium and lithium **or** the **outer** electron is a same /similar distance from the nucleus **or** the **outer** electron is in the same / 2s orbital (the value for) beryllium is higher than boron • as the **outer** electron in boron is in the (2)**p** orbital / subshell (rather than the 2s orbital in beryllium) • the effect of the additional proton / increased nuclear charge in boron is outweighed **by** increased shielding / repulsion (from inner subshell)	 **(1)** **(1)** **(1)** **(1)**	Allow reverse argument throughout Penalise omission of 'outer' once only Ignore electron configurations unless incorrect Allow greater proton number Ignore reference to atomic or ionic radius Allow outer electron in B is in a higher energy level Allow **by** increased distance from the nucleus (of the **outer** electron in B)	**(4)**

Question Number	Answer	Additional Guidance	Mark
2(c)	An answer that makes reference to the following point: • correct equation with state symbols	$Be^{+}(g) \rightarrow Be^{2+}(g) + e^{(-)}$ Allow $Be^{+}(g) - e^{(-)} \rightarrow Be^{2+}(g)$ Ignore state symbol for the electron Do not allow ⇌	**(1)**

Question Number	Answer	Mark
2(d)	**The only correct answer is C** (4s) ***A*** *is not correct because this would be Mg* ***B*** *is not correct because this could relate to a p-block element in period 3* ***D*** *is not correct because this could relate to a p-block element in period 4*	**(1)**

Question Number	Answer	Mark
2(e)	**The only correct answer is A** (S^{2-}) ***B*** *is not correct because the ionic radius of* Cl^- *is smaller than* S^{2-} *as it has one more proton* ***C*** *is not correct because the ionic radius of* K^+ *is smaller than both* S^{2-} *and* Cl^- *as it has more protons* ***D*** *is not correct because* Ca^{2+} *has the smallest ionic radius since it has the most protons*	**(1)**

Question Number	Answer		Additional Guidance	Mark
2(f)	An answer that makes reference to the following points: • hydrogen bonding is the strongest intermolecular force • there is hydrogen bonding between H_2O (molecules) **and** between HF (molecules) • H_2O has **two** hydrogen bonds (per molecule, as it has two lone pairs on the oxygen) and so its boiling temperature is higher than HF • there are permanent dipoles between the HCl molecules • there are stronger / more London forces between HI (molecules) than HCl (molecules) because there are more **electrons** (in a molecule of HI) • (the increased) London forces between HI (molecules) outweigh the permanent dipole forces (between HCl (molecules)	 (1) (1) (1) (1) (1) (1)	Penalise reference to covalent bonds breaking once only Allow H bonds take more energy to break than other types of intermolecular force Allow water can form twice as many hydrogen bonds (than HF) Ignore H_2O has more hydrogen bonds Allow HCl has dipole-dipole (forces) Ignore HI has a permanent dipole Accept van der Waals / temporary dipole – induced dipole Allow London forces require more energy to break / be overcome than permanent dipole (forces) Allow London forces outweigh the (greater) electronegativity difference between H and Cl	(6)

(Total for Question 2 = 16 marks)

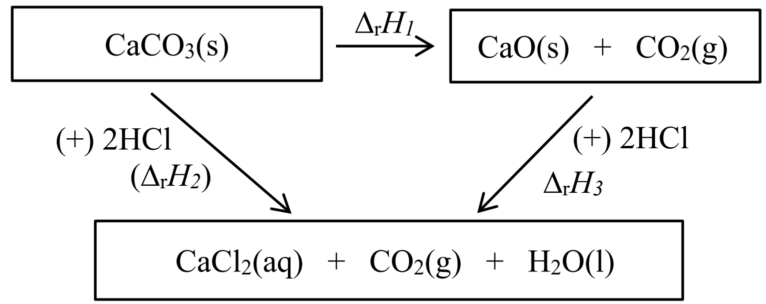
Question Number	Answer	Additional Guidance	Mark
3(a)	An answer that makes reference to the following point: • heat energy must be supplied so the energy change is not just due to the thermal decomposition reaction **or** it is difficult to determine when the (decomposition) reaction is complete **or** it's difficult to (accurately) measure the temperature of a solid (whilst heating)	Allow it is impossible to measure ΔT when heat energy is supplied / cannot measure temperature (easily) whilst heating Ignore the reaction is not complete Allow you cannot measure the temperature of a solid (easily)	**(1)**

Question Number	Answer	Additional Guidance	Mark
3(b)(i) **Clip all of (b)**	• correct values in table for mass and temperature	(see table below)	**(1)**

Substance	Value
Mass of weighing boat with calcium carbonate / g	(4.30)
Mass of weighing boat after emptying out calcium carbonate / g	(0.20)
Mass of calcium carbonate used / g	**4.10**
Start temperature / °C	(19.0)
Highest temperature / °C	**24.5**
Temperature change / °C	(5.5)

Question Number	Answer	Additional Guidance	Mark
3(b)(ii)	• mol of HCl **(1)** • mol of HCl required **and** more mol HCl present than required **(1)**	<u>Example of calculation</u> $= 3.00 \times \frac{30}{1000} = 0.090$ $= 0.041 \times 2 = 0.082$ **and** $0.09 > 0.082$ (mol) Allow $0.090 \div 2 = 0.045$ (mol $CaCO_3$ that you would need to react with 0.09 mol HCl and) $0.045 > 0.041$ (mol) Ignore SF Allow calculation of excess HCl by subtraction from 0.090	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(b)(iii)	• energy change (Q) for Reaction 2 **(1)** • enthalpy change ($\Delta_r H_2$) for Reaction 2 **(1)** • answer with negative sign **(1)**	<u>Example of calculation</u> energy change $= 30 \times 4.18 \times 5.5$ $= 689.7$ (J) / 0.6897 (kJ) Ignore any signs in M1 enthalpy change $= \frac{0.6897}{0.041}$ (kJ) / $\frac{689.7}{0.041}$ (J) $= -16.822$ (kJ mol^{-1}) / $-16\,822$ J mol^{-1} / -17.0 (kJ mol^{-1}) / $-17\,000$ J mol^{-1} Accept correct answer with no working Allow TE throughout Ignore SF except 1SF	**(3)**

Question Number	Answer	Additional Guidance	Mark
3(b)(iv)	An answer that makes reference to the following points: • correct species with state symbols in the bottom box **(1)** • arrow on left hand side in correct direction **and** labelled with 2HCl((aq)) **(1)**	<u>Example of cycle</u>  Ignore any additional labels for arrows, including values or 'Reaction 1' and 'Reaction 2' unless incorrect	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(b)(v)	• calculation of enthalpy change of thermal decomposition of calcium carbonate	<u>Example of calculation</u> $\Delta_r H_1 = -16.8 - -176.3 = (+)\ 159.5\ \text{kJ mol}^{-1}$ TE on their incorrect value from 3(b)(iii) No TE on incorrect cycle	**(1)**

Question Number	Answer		Additional Guidance	Mark
3(c)(i)	An explanation that makes reference to the following points: • calculation of $\Delta S^{\ominus}_{system}$ • calculation of $\Delta G^{\ominus}$ • reason why not feasible Alternative for M2 and 3 using ΔS_{total} • $\Delta S_{surroundings} = -\frac{178\ 200}{298} = -597.99$ (J K^{-1} mol^{-1}) • $\Delta S_{total} = 160.4 - 597.99 = -437.59$ (J K^{-1} mol^{-1}) and Value is negative and so not feasible	 **(1)** **(1)** **(1)** **(1)** **(1)**	Example of calculation = (39.7 + 213.6) – (92.9) = (+) 160.4 (J K^{-1} mol^{-1}) / (+) 0.1604 (kJ K^{-1} mol^{-1}) ($\Delta G = \Delta H - T\Delta S_{system}$) = (+ 178.2 × 1000) – (298 × 160.4) = (+) 130 400 (J mol^{-1})/ (+) 130.4 (kJ mol^{-1}) Allow TE from M1 to M2 ΔG positive / > 0 so not feasible No TE on negative value of ΔG Ignore minor rounding error in decimal places of ΔS_{total} Ignore SF except 1SF	**(3)**

Question Number	Answer	Additional Guidance	Mark
3(c)(ii)	• rearrangement of ΔG expression and calculation of feasible temperature **(1)** • conversion to degrees Celsius **(1)**	<u>Example of calculation</u> $T = \Delta H / \Delta S_{system}$ $T = 178.2 / 0.1604 = 1111$ (K) Allow 1110 (K) for M1 1111 – 273 = 838 (ºC) Allow 1110 – 273 = 837 (ºC) Accept method that uses $\Delta S_{total} = 0$ $\Delta S_{total} = 0 = 160.4 - (178\ 200 / T)$ $T = -178\ 200 / -160.4 = 1111$(K) 1111 – 273 = 838 838 / 837 with or without working scores both marks Do not award 840ºC Allow TE from M1 to M2 for values > − 273 ºC	**(2)**

Question Number	Answer		Additional Guidance	Mark
3(d)	An explanation that makes reference to the following points:		Accept reverse argument Penalise reference to just Mg or Ca once only	**(3)**
	• Mg^{2+} is a smaller cation / ion / has a smaller ionic radius / has a greater charge density	**(1)**	Ignore 'more covalent character' / comments related to atomic radius unless they contradict the relative size of the ions	
	• Mg^{2+} polarises the carbonate / CO_3^{2-} / anion more	**(1)**	Allow Mg^{2+} has greater polarising power / Mg^{2+} distorts the electron cloud more Ignore Mg^{2+} polarises the C-O bond more	
	• (so in $MgCO_3$) the bond between C and O is weakened more	**(1)**	Allow bond(s) **within** the anion are weakened more Allow C-O (bond) / C=O (bond) is weakened more	

(Total for Question 3 = 18 marks)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>4(a)</td><td>
• calculation of moles at equilibrium (1)
• calculation of mole fractions (1)
• calculation of partial pressures (1)
• expression for K_p (1)
• value of K_p and units (1)
</td><td>
<u>Example of calculation</u>
<table>
<tr><th></th><th>$C_2H_4(g)$</th><th>$H_2O(g)$</th><th>$C_2H_5OH(g)$</th></tr>
<tr><td>Initial moles</td><td>90.0</td><td>54.0</td><td>0.0</td></tr>
<tr><td>Change in moles</td><td>−4.5</td><td>−4.5</td><td>+4.5</td></tr>
<tr><td>Equilibrium moles</td><td>85.5</td><td>49.5</td><td>4.5</td></tr>
<tr><td>Mole fraction</td><td>85.5 ÷ 139.5
= 0.6129</td><td>49.5 ÷ 139.5
= 0.3548</td><td>4.5 ÷ 139.5
= 0.0323</td></tr>
<tr><td>Partial pressure</td><td>0.6129 × 60
= 36.77</td><td>0.3548 × 60
= 21.29</td><td>0.0323 × 60
= 1.94</td></tr>
</table>
$K_p = \frac{p(C_2H_5OH)}{p(C_2H_4)\,p(H_2O)}$
Allow p inside bracket
Allow pp
Allow without brackets
Do not award square brackets

$K_p = \frac{1.94}{(36.77 \times 21.29)}$
$= 0.00248 / 2.48 \times 10^{-3} / 0.0025 / 2.5 \times 10^{-3}$ atm^{-1}
Allow TE throughout
Ignore SF except for 1 SF
Correct answer with no working scores M1 to M3 and M5
K_p with no early rounding = 0.00247 / 2.47×10^{-3}
</td><td>(5)</td></tr>
</table>

Question Number	Answer	Additional Guidance	Mark
4(b)(i)	An answer that makes reference to the following points: • (so increased pressure) will increase the yield of ethanol **(1)** • because the position of equilibrium will move to the RHS as there are less moles / molecules / particles (of gas) on the RHS **(1)**	Mark points independently Allow because the position of equilibrium will move to the products side as there are less moles / molecules (of gas) on the RHS Allow forward direction for RHS	**(2)**

Question Number	Answer	Mark
4(b)(ii)	**The only correct answer is C** (decreasing the temperature) ***A*** *is not correct as changing the catalyst might affect the rate at which equilibrium was established, but would have no effect on the value of* K_p ***B*** *is not correct because although increasing the pressure would allow equilibrium to be established faster, this would not affect the value of* K_p ***D*** *is not correct because increasing the volume would mean that equilibrium would be established more slowly, but this would not affect the value of* K_p.	**(1)**

(Total for Question 4 = 8 marks)

Question Number	Answer	Mark
5(a)	**The only correct answer is C** (acid H_3O^+, conjugate base H_2O) ***A** is not correct as H_2O is not the conjugate base of HNO_3* ***B** is not correct because the NO_3^- is the conjugate base and HNO_3 is the acid* ***D** is not correct because the H_2O is the conjugate base and H_3O^+ is the acid*	**(1)**

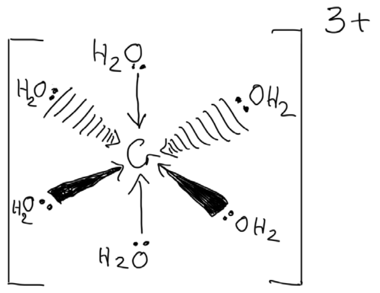
Question Number	Answer	Additional Guidance	Mark
5(b)	An answer that makes reference to the following point: • (pH =) $-\log_{10}[H^+(aq)]$ **or** (pH =) $-\log_{10}[H_3O^+(aq)]$	Allow log / lg for $\log_{10}$ Ignore missing (aq) Do not award $-$log conc H^+ Do not award round brackets / no brackets for concentration, but allow round brackets around the square brackets e.g. $-\log_{10}([H^+(aq)])$	**(1)**

Question Number	Answer	Mark
5(c)	**The only correct answer is B** (3.16×10^{-5}) ***A*** *is not correct because this is the value for the* H^+ *concentration* ***C*** *is not correct as the value for the concentration has been doubled* ***D*** *is not correct because* $10^{4.5}$ *has been used instead of* $10^{-4.5}$	**(1)**

(Total for Question 5 = 3 marks)

Question Number	Answer	Mark
6(a)(i)	**The only correct answer is D** ([Ar] $3d^5 4s^1$, [Ar] $3d^3$) ***A*** *is not correct because neither of the electronic configurations is correct* ***B*** *is not correct because the Cr atom is correct, but the* Cr^{3+} *ion is not correct* ***C*** *is not correct because the Cr atom is not correct, but the* Cr^{3+} *ion is correct*	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(a)(ii)	An answer that makes reference to the following point: • (Cr) is a transition metal because it forms (one or more stable) ion(s) with incompletely filled *d*-orbital(s) / *d*-subshell	Ignore *d*-shell	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	An answer that makes reference to the following points: • six water ligands around chromium ion with **3D** structure indicated (ignore connectivity for M1) **(1)** • dative bonds between water ligands and chromium indicated by arrows from the **oxygen** of the water ligands to the chromium ion **or** bonds to Cr from lone pairs shown on the oxygen atoms **(1)**	<u>Example of structure</u>  Ignore missing square brackets and charge Ignore incorrect charge Ignore comments linked to shape names / bond angles Allow bonds labelled as dative / co-ordinate	**(2)**

Question Number	Answer	Additional Guidance	Mark
6(b)(ii)	An answer that makes reference to the following point: • octahedral	Allow octahedron Do not award octagonal / octagon	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(c)	An answer that makes reference to the following points: • equation for $[Cr(OH)_3(H_2O)_3]$ with H^+ **(1)** • equation for $[Cr(OH)_3(H_2O)_3]$ with OH^- **(1)** • all state symbols correct **(1)**	$[Cr(OH)_3(H_2O)_3](s) + 3H^+(aq) \rightarrow [Cr(H_2O)_6]^{3+}(aq)$ $[Cr(OH)_3(H_2O)_3](s) + H^+(aq) \rightarrow [Cr(H_2O)_4(OH)_2]^+(aq)$ $[Cr(OH)_3(H_2O)_3](s) + 2H^+(aq) \rightarrow [Cr(H_2O)_5(OH)]^{2+}(aq)$ $[Cr(OH)_3(H_2O)_3](s) + 3OH^-(aq) \rightarrow [Cr(OH)_6]^{3-}(aq) + 3H_2O(l)$ $[Cr(OH)_3(H_2O)_3](s) + OH^-(aq) \rightarrow [Cr(H_2O)_2(OH)_4]^-(aq) + H_2O(l)$ $[Cr(OH)_3(H_2O)_3](s) + 2OH^-(aq) \rightarrow [Cr(H_2O)(OH)_5]^{2-}(aq) + 2H_2O(l)$ M3 dependent on M1 **and** M2 No TE for state symbol mark Allow reversible arrows Penalise full equations once only Ignore missing square brackets	**(3)**

Question Number	Answer	Additional Guidance	Mark
6(d)	An answer that makes reference to the following point: • ligand exchange / ligand substitution	Allow ligand replacement	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(e)(i)	An explanation that makes reference to the following points: • (when a ligand approaches) d-orbitals split or d-subshell splits (into higher and lower energy levels) **(1)** • electron is promoted / d−d transition / excited **(1)** • absorbing (visible) **light** (energy) / photons (of specific wavelength / frequency) **(1)** • complementary colour / seen / transmitted / reflected **(1)**	Do not award the splitting of a single d −orbital Ignore d-shell Ignore electrons returning to ground state Allow remaining light seen / transmitted / reflected Do not award any reference to emission (of light)	**(4)**

Question Number	Answer	Additional Guidance	Mark
6(e)(ii)	An answer that makes reference to the following point: • (colours are different because) with different ligands the energy gap / splitting / ΔE between the d-orbitals is different **or** • (colours are different because) with different coordination numbers as the energy gap / splitting / ΔE between the d-orbitals is different	Allow different ligands / coordination number so energy needed to promote electron(s) is different Allow different ligand / coordination number changes the **wavelength / frequency** of light absorbed Ignore different oxidation states (of metal ion)	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(f)(i)	An answer that makes reference to the following points: • multiplication of equation (a) by 2 **and** (1) multiplication of equation (b) by 3 • overall equation (1)	$2CrO_4^{2-}(aq) + 8H_2O(l) + 6e^- \rightleftharpoons 2Cr(OH)_3(s) + 10OH^-(aq)$ Accept half equation for the chromium written as an oxidation $3H_2O_2(aq) + 6e^- \rightleftharpoons 6OH^-(aq)$ M1 can be shown by use of $2Cr(OH)_3 : 3\ H_2O_2$ in attempted equation or via equations in stem of question $2Cr(OH)_3(s) + 3H_2O_2(aq) + 4OH^-(aq) \rightarrow 2CrO_4^{2-}(aq) + 8H_2O(l)$ Allow multiples Ignore state symbols even if incorrect Allow reversible arrow for full equation as long as reaction is written in the forward direction Award 2 marks for correct overall equation with no working	**(2)**

Question Number	Answer	Additional Guidance	Mark
6(f)(ii)	• calculation of $E^\ominus_{cell}$ value (1) • $E^\ominus_{cell}$ / answer is positive / > 0 **and** the reaction is (thermodynamically) feasible (1)	<u>Example of calculation</u> $E^\ominus_{cell} = 0.13 + 0.88 = (+)\ 1.01$ (V) Allow correct answer without calculation Allow as TE if negative $E^\ominus_{cell}$ calculated Answer is negative / < 0 **and** the reaction is **not** (thermodynamically) feasible	**(2)**

Question Number	Answer	Mark
6(f)(iii)	**The only correct answer is A** ($E^\ominus_{cell}$ is directly proportional to ln K) ***B*** *is not correct because* $E^\ominus_{cell}$ *is directly proportional to* ΔS_{total}*, and not* ΔS_{system} ***C*** *is not correct because* $E^\ominus_{cell}$ *is directly proportional to* ΔS_{total}*, and not ln* ΔS_{total} ***D*** *is not correct because* $E^\ominus_{cell}$ *is not directly proportional to K but to ln K*	**(1)**

(Total for Question 6 = 19 marks)

Question Number	Answer	Mark
7(a)	**The only correct answer is C** (the energy change when 1 mol of an ionic substance is formed from its gaseous ions) ***A*** *is not correct because it is the energy change not the energy absorbed* ***B*** *is not correct because it is gaseous ions and not the elements in their standard states* ***D*** *is not correct because it is the energy change and gaseous ions*	**(1)**

Question Number	Answer	Mark
7(b)	**The only correct answer is A** (NaCl) ***B*** *is not correct because the I^- ion is larger than the Cl^- ion and so the lattice energy is less exothermic than that of NaCl* ***C*** *is not correct because the K^+ ion is larger than Na^+ and so the lattice energy is less exothermic than that of NaCl* ***D*** *is not correct because K^+ and I^- are both larger than Na^+ and Cl^- respectively and so the lattice energy is less exothermic than that of NaCl*	**(1)**

Question Number	Answer	Mark
7(c)	**The only correct answer is B** (NaI) ***A*** *is not correct because NaCl has a smaller difference between the experimental and theoretical lattice energies because the* Cl^- *ion is not polarised as much as* I^- *by the* Na^+ *ion as it is small compared to* I^- ***C*** *is not correct because KCl has a smaller difference between the experimental and theoretical lattice energies because the* Cl^- *ion is not polarised as much as* I^- *by the* K^+ *ion as it is small compared to* I^- ***D*** *is not correct because the difference in polarisation between* K^+ *and* I^- *is not as great as between* Na^+ *and* I^- *because* K^+ *is a larger ion than* Na^+	**(1)**

(Total for Question 7 = 3 marks)

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*8</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).</td>
<td>(6)</td>
</tr>
</table>

*8	Indicative content • **IP1 (similarity: mechanism of action)** both (increase the rate of a reaction) by lowering the activation energy by providing an alternative pathway / route for the reaction • **IP2** **(similarity: oxidation number changes)** both involve the change of oxidation numbers and then the return to the original oxidation number • **IP3 (V_2O_5 mechanism)** reactants / SO_2 and O_2 **adsorb(s)**, (reactant bonds weaken / break) **and** product / SO_3 **desorb(s)** **or** **(Fe^{2+} mechanism)** (the) positive Fe^{2+} ions **attract** the negative $S_2O_8^{2-}$ ions • **IP4 (difference: homogeneous / heterogeneous)** V_2O_5 is heterogeneous / different phase / state (as reactants) **and** Fe^{2+} is homogeneous / same phase / state (as reactants) • **IP5 (Equation 1)** $V_2O_5(s) + SO_2(g) \rightarrow V_2O_4(s) + SO_3(g)$ **and** $V_2O_4(s) + \frac{1}{2}O_2(g) \rightarrow V_2O_5(s)$ • **IP6 (Equation 2)** $S_2O_8^{2-}(aq) + 2Fe^{2+}(aq) \rightarrow 2Fe^{3+}(aq) + 2SO_4^{2-}(aq)$ **and** $2Fe^{3+}(aq) + 2I^{-}(aq) \rightarrow I_2(aq) + 2Fe^{2+}(aq)$	Ignore any references to colours of species in reactions Allow via illustration of correct changes in oxidation state Allow V_2O_5 is **reduced** to V_2O_4, which is then **oxidised** to V_2O_5 and Fe^{2+} is **oxidised** to Fe^{3+} which is then **reduced** to Fe^{2+} Ignore catalyst is reformed / regenerated Ignore sulfur/ iodine oxidation numbers Do not award autocatalysis Allow $S_2O_8^{2-}$ and I^- **repel** (so the reaction starts slowly) Allow specific states mentioned – V_2O_5 is a solid and the reactants are gases and Fe^{2+} and the reactants are all in aqueous solution Allow multiples Ignore state symbols for IP5 and IP6 If IP5 and IP6 not given allow 1IP for any two correct equations	**(6)**

(Total for Question 8 = 6 marks)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>9(a)</td><td>titre 3 correct
and
initial burette reading 4 correct</td><td><u>Example of table</u>
<table>
<tr><th>Titration number</th><th>1</th><th>2</th><th>3</th><th>4</th></tr>
<tr><td>Final burette reading / cm^3</td><td>(15.90)</td><td>(24.00)</td><td>(15.30)</td><td>(25.00)</td></tr>
<tr><td>Initial burette reading / cm^3</td><td>(0.00)</td><td>(8.45)</td><td>(0.05)</td><td>9.35</td></tr>
<tr><td>Titre / cm^3</td><td>(15.90)</td><td>(15.55)</td><td>15.25</td><td>(15.65)</td></tr>
</table></td><td>(1)</td></tr>
</table>

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>9(b)</td><td>An answer that makes reference to the following point:
the mean / average of the concordant titres</td><td>Allow titres 2 and 4 / 15.55 and 15.65 to identify the relevant titres

Do not award all four titrations added together and divided by four</td><td>(1)</td></tr>
</table>

Question Number	Answer	Additional Guidance	Mark
9(c)	An answer that makes reference to the following points: • (from) colourless **(1)** • (to) (pale) pink **(1)**	 Do not award pink − purple / dark pink / purple / red Allow one mark for correct colours reversed	**(2)**

Question Number	Answer	Additional Guidance	Mark
9(d)	• moles of $KMnO_4(aq)$ / $MnO_4^-(aq)$ used in titration **(1)** • moles H_2O_2 in 25.0 cm^3 of the diluted sanitiser **(1)** • moles H_2O_2 in the 250 cm^3 of solution = moles in 10.0 cm^3 of hand sanitiser **(1)** • mass H_2O_2 in 10 cm^3 hand sanitiser **(1)** • % by mass of H_2O_2 in hand sanitiser **and** this is within the (WHO) guidelines **(1)**	Example of calculation $= 0.0200 \times \frac{15.60}{1000} = 3.12 \times 10^{-4}$ / 0.000312 (mol) $= (3.12 \times 10^{-4} / 2) \times 5 = 7.80 \times 10^{-4}$ / 0.000780 (mol) $= 7.80 \times 10^{-4} \times 10 = 7.80 \times 10^{-3}$ / 0.00780 (mol) M3 could be carried out before M2 $= 34 \times 7.80 \times 10^{-3} = 0.2652$ (g) $= \frac{0.2652}{8.2} \times 100 = 3.23$ (%) Ignore SF except 1 SF Allow TE throughout unless greater than 100% Allow alternative method for M4 and M5 using concentrations of H_2O_2 in mol dm^{-3}	**(5)**

Question Number	Answer	Additional Guidance	Mark
9(e)	• pipette uncertainty **(1)** • burette uncertainty **(1)**	Example of calculation $= \frac{0.04}{25} \times 100 = (\pm)\ 0.16\%$ $= \frac{0.05}{15.55} \times 2 \times 100 = (\pm)\ 0.643\ /\ 0.64\%$ Ignore absence of labels 'pipette' and 'burette' If labels given but wrong way round allow 1 mark for 2 correct numerical values Allow any SF except 1 SF Accept correct answers without working Penalise 1 SF once only	**(2)**

(Total for Question 9 = 11 marks)

TOTAL FOR PAPER = 90 MARKS

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