AQA

A-level
CHEMISTRY
7405/1

Paper 1 Inorganic and Physical Chemistry

Mark scheme

June 2024

Version: 1.0 Final

246A74051/MS

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

No student should be disadvantaged on the basis of their gender identity and/or how they refer to the gender identity of others in their exam responses.

A consistent use of 'they/them' as a singular and pronouns beyond 'she/her' or 'he/him' will be credited in exam responses in line with existing mark scheme criteria.

Further copies of this mark scheme are available from aqa.org.uk

AS and A-Level Chemistry
Mark Scheme Instructions for Examiners

1. General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- the typical answer or answers which are expected
- extra information to help the examiner make his or her judgement and help to delineate what is acceptable or not worthy of credit or, in discursive answers, to give an overview of the area in which a mark or marks may be awarded.

The extra information in the 'Comments' column is aligned to the appropriate answer in the left-hand part of the mark scheme and should only be applied to that item in the mark scheme.

You should mark according to the contents of the mark scheme. If you are in any doubt about applying the mark scheme to a particular response, consult your Team Leader.

At the beginning of a part of a question a reminder may be given, for example: where consequential marking needs to be considered in a calculation; or the answer may be on the diagram or at a different place on the script.

In general the right-hand side of the mark scheme is there to provide those extra details which might confuse the main part of the mark scheme yet may be helpful in ensuring that marking is straightforward and consistent.

The use of M1, M2, M3 etc in the right-hand column refers to the marking points in the order in which they appear in the mark scheme. So, M1 refers to the first marking point, M2 the second marking point etc.

2. Emboldening

2.1 In a list of acceptable answers where more than one mark is available 'any **two** from' is used, with the number of marks emboldened. Each of the following bullet points is a potential mark.

2.2 A bold **and** is used to indicate that both parts of the answer are required to award the mark.

2.3 Alternative answers acceptable for a mark are indicated by the use of **OR**. Different terms in the mark scheme are shown by a / ; eg allow smooth / free movement.

3. Marking points

3.1 Marking of lists

This applies to questions requiring a set number of responses, but for which students have provided extra responses. The general 'List' principle to be followed in such a situation is that 'right + wrong = wrong'.

Each error / contradiction negates each correct response. So, if the number of error / contradictions equals or exceeds the number of marks available for the question, no marks can be awarded.

However, responses considered to be neutral (often prefaced by 'Ignore' in the mark scheme) are not penalised.

For example, in a question requiring 2 answers for 2 marks:

Correct answers	Incorrect answers (ie incorrect rather than neutral)	Mark (2)	Comment
1	0	1	
1	1	1	They have not exceeded the maximum number of responses so there is no penalty.
1	2	0	They have exceeded the maximum number of responses so the extra incorrect response cancels the correct one.
2	0	2	
2	1	1	
2	2	0	
3	0	2	The maximum mark is 2
3	1	1	The incorrect response cancels out one of the two correct responses that gained credit.
3	2	0	Two incorrect responses cancel out the two marks gained.
3	3	0	

3.2 Marking procedure for calculations

Full marks should be awarded for a correct numerical answer, without any working shown, unless the question states ‘Show your working’ or ‘justify your answer’. In this case, the mark scheme will clearly indicate what is required to gain full credit.

If an answer to a calculation is incorrect and working is shown, process mark(s) can usually be gained by correct substitution / working and this is shown in the ‘Comments’ column or by each stage of a longer calculation.

3.3 Errors carried forward, consequential marking and arithmetic errors

Allowances for errors carried forward are most likely to be restricted to calculation questions and should be shown by the abbreviation ECF or consequential in the marking scheme.

An arithmetic error should be penalised for one mark only unless otherwise amplified in the marking scheme. Arithmetic errors may arise from a slip in a calculation or from an incorrect transfer of a numerical value from data given in a question.

3.4 Equations

In questions requiring students to write equations, state symbols are generally ignored unless otherwise stated in the ‘Comments’ column.

Examiners should also credit correct equations using multiples and fractions unless otherwise stated in the 'Comments' column.

3.5 Oxidation states

In general, the sign for an oxidation state will be assumed to be positive unless specifically shown to be negative.

3.6 Interpretation of 'it'

Answers using the word 'it' should be given credit only if it is clear that the 'it' refers to the correct subject.

3.7 Phonetic spelling

The phonetic spelling of correct scientific terminology should be credited **unless** there is a possible confusion with another technical term or if the question requires correct IUPAC nomenclature.

3.8 Brackets

(…..) are used to indicate information which is not essential for the mark to be awarded but is included to help the examiner identify the sense of the answer required.

3.9 Ignore / Insufficient / Do not allow

Ignore or insufficient is used when the information given is irrelevant to the question or not enough to gain the marking point. Any further correct amplification could gain the marking point.

Do **not** allow means that this is a wrong answer which, even if the correct answer is given, will still mean that the mark is not awarded.

3.10 Marking crossed out work

Crossed out work that **has not been** replaced should be marked as if it were not crossed out, if possible. Where crossed out work **has been** replaced, the replacement work and not the crossed out work should be marked.

3.11 Reagents

The command word 'Identify', allows the student to choose to use **either** the name **or** the formula of a reagent in their answer. In some circumstances, the list principle may apply when both the name and the formula are used. Specific details will be given in mark schemes.

The guiding principle is that a reagent is a chemical which can be taken out of a bottle or container. Failure to identify complete reagents **will be penalised**, but follow-on marks (eg for a subsequent equation or observation) can be scored from an incorrect attempt (possibly an incomplete reagent) at the correct reagent. Specific details will be given in mark schemes.

For example, **no credit** would be given for:

- the cyanide ion or CN^- when the reagent should be potassium cyanide or KCN;
- the hydroxide ion or OH^- when the reagent should be sodium hydroxide or NaOH;
- the $Ag(NH_3)_2^+$ ion when the reagent should be Tollens' reagent (or ammoniacal silver nitrate). In this example, no credit is given for the ion, but credit could be given for a correct observation following on from the use of the ion. Specific details will be given in mark schemes.

In the event that a student provides, for example, **both** KCN and cyanide ion, it would be usual to ignore the reference to the cyanide ion (because this is not contradictory) and credit the KCN. Specific details will be given in mark schemes.

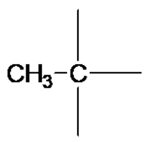
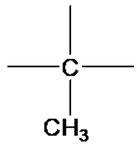
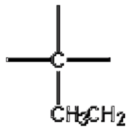
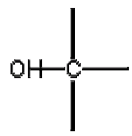
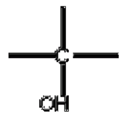
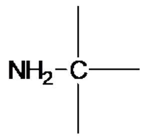
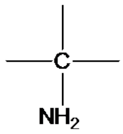
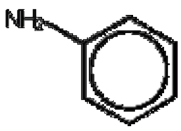
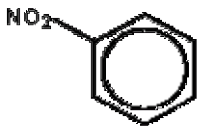
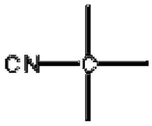
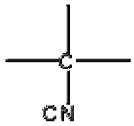
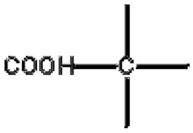
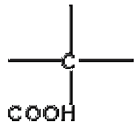
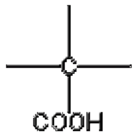
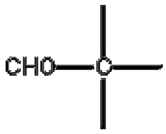
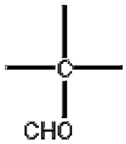
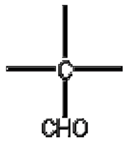
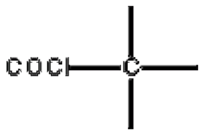
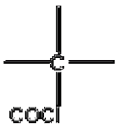
3.12 Organic structures

Where students are asked to draw organic structures, unless a specific type is required in the question and stated in the mark scheme, these may be given as displayed, structural or skeletal formulas or a combination of all three as long as the result is unambiguous.

In general

- Displayed formulae must show all of the bonds and all of the atoms in the molecule, but need not show correct bond angles.
- Skeletal formulae must show carbon atoms by an angle or suitable intersection in the skeleton chain. Functional groups must be shown and it is essential that all atoms other than C atoms are shown in these (except H atoms in the functional groups of aldehydes, secondary amines and N-substituted amides which do not need to be shown).
- Structures must not be ambiguous, e.g. 1-bromopropane should be shown as $CH_3CH_2CH_2Br$ and not as the molecular formula C_3H_7Br which could also represent the isomeric 2-bromopropane.
- Bonds should be drawn correctly between the relevant atoms. This principle applies in all cases where the attached functional group contains a carbon atom, eg nitrile, carboxylic acid, aldehyde and acid chloride. The carbon-carbon bond should be clearly shown. Wrongly bonded atoms will be penalised **on every occasion**. (see the examples below)
- The same principle should also be applied to the structure of alcohols. For example, if students show the alcohol functional group as C ─ HO, they should be penalised **on every occasion**.
- Latitude should be given to the representation of C ─ C bonds in alkyl groups, given that CH_3─ is considered to be interchangeable with H_3C─ even though the latter would be preferred.
- Similar latitude should be given to the representation of amines where NH_2─ C will be allowed, although H_2N─ C would be preferred.
- Poor presentation of vertical C ─ CH_3 bonds or vertical C ─ NH_2 bonds should **not** be penalised. For other functional groups, such as ─ OH and ─ CN, the limit of tolerance is the half-way position between the vertical bond and the relevant atoms in the attached group.

By way of illustration, the following would apply.

				
allowed	**allowed**	not allowed	not allowed	not allowed
				
allowed	**allowed**	**allowed**	**allowed**	not allowed
				
not allowed	not allowed	not allowed	not allowed	not allowed
				
not allowed	not allowed	not allowed	not allowed	not allowed

- Representation of CH_2 by $C–H_2$ will be penalised
- Some examples are given here of **structures** for specific compounds that should **not** gain credit (but, exceptions **may** be made in the context of balancing equations)

CH_3COH	for	ethanal
CH_3CH_2HO	for	ethanol
$OHCH_2CH_3$	for	ethanol
C_2H_6O	for	ethanol
CH_2CH_2	for	ethene
$CH_2.CH_2$	for	ethene
$CH_2:CH_2$	for	ethene

- Each of the following **should gain credit** as alternatives to correct representations of the structures.

$CH_2 = CH_2$	for	ethene, $H_2C=CH_2$
$CH_3CHOHCH_3$	for	propan-2-ol, $CH_3CH(OH)CH_3$

- In most cases, the use of 'sticks' to represent C ─ H bonds in a structure should **not** be penalised. The exceptions to this when "sticks" will be penalised include
  - structures in mechanisms where the C ─ H bond is essential (eg elimination reactions in halogenoalkanes and alcohols)
  - when a displayed formula is required
  - when a skeletal structure is required or has been drawn by the candidate.

3.13 Organic names

As a general principle, non-IUPAC names or incorrect spelling or incomplete names should **not** gain credit. Some illustrations are given here.

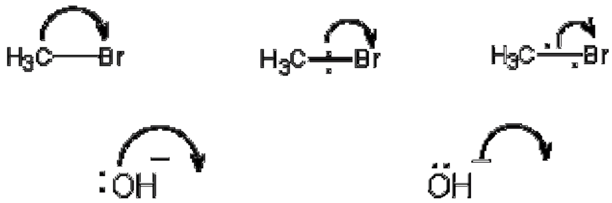
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

but-2-ol	should be **butan-2-ol**
2-hydroxybutane	should be **butan-2-ol**
butane-2-ol	should be **butan-2-ol**
2-butanol	should be **butan-2-ol**
ethan-1,2-diol	should be **ethane-1,2-diol**
2-methpropan-2-ol	should be **2-methylpropan-2-ol**
2-methylbutan-3-ol	should be **3-methylbutan-2-ol**
3-methylpentan	should be **3-methylpentane**
3-mythylpentane	should be **3-methylpentane**
3-methypentane	should be **3-methylpentane**
propanitrile	should be **propanenitrile**
aminethane	should be **ethylamine** (although aminoethane can gain credit)
2-methyl-3-bromobutane	should be **2-bromo-3-methylbutane**
3-bromo-2-methylbutane	should be **2-bromo-3-methylbutane**
3-methyl-2-bromobutane	should be **2-bromo-3-methylbutane**
2-methylbut-3-ene	should be **3-methylbut-1-ene**
difluorodichloromethane	should be **dichlorodifluoromethane**

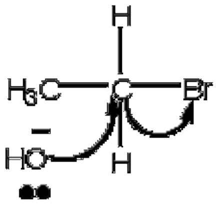
3.14 Organic reaction mechanisms

Curly arrows should originate either from a lone pair of electrons or from a bond.

The following representations should not gain credit **and will be penalised each time** within a clip.



For example, the following would score zero marks



When the curly arrow is showing the formation of a bond to an atom, the arrow can go directly to the relevant atom, alongside the relevant atom or **more than half-way** towards the relevant atom.

In free-radical substitution:

- the absence of a radical dot should be penalised **once only** within a clip.
- the use of half-headed arrows is not required, but the use of double-headed arrows or the incorrect use of half-headed arrows in free-radical mechanisms should be penalised **once only** within a clip.

The correct use of skeletal formulae in mechanisms is acceptable, but where a C-H bond breaks, both the bond and the H must be drawn to gain credit.

3.15 Extended responses

For questions marked using a 'Levels of Response' mark scheme:

Level of response mark schemes are broken down into three levels, each of which has a descriptor. Each descriptor contains two statements. The first statement is the Chemistry content statement and the second statement is the communication statement.

Determining a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the Chemistry content descriptor for that level. The descriptor for the level indicates the qualities that might be seen in the student's answer for that level. If it meets the lowest level, then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level.

Once the level has been decided, the mark within the level is determined by the communication statement:

• If the answer completely matches the communication descriptor, award the higher mark within the level.

• If the answer does not completely match the communication descriptor, award the lower mark within the level.

The exemplar materials used during standardisation will help you to determine the appropriate level. There will be an exemplar in the standardising materials which will correspond with each level of the mark scheme and for each mark within each level. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the exemplar to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the exemplar.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other chemically valid points. Students may not have to cover all of the points mentioned in the indicative content to reach the highest level of the mark scheme. The mark scheme will state how much chemical content is required for the highest level.

An answer which contains nothing of relevance to the question must be awarded no marks.

For other extended response answers:

Where a mark scheme includes linkage words (such as 'therefore', 'so', 'because' etc), these are optional. However, a student's marks for the question may be limited if they do not demonstrate the ability to construct and develop a sustained line of reasoning which is coherent, relevant, substantiated and logically structured. In particular answers in the form of bullet pointed lists may not be awarded full marks if there is no indication of logical flow between each point or if points are in an illogical order.

The mark schemes for some questions state that the maximum mark available for an extended response answer is limited if the answer is not coherent, relevant, substantiated and logically structured. During the standardisation process, the Lead Examiner will provide marked exemplar material to demonstrate answers which have not met these criteria. You should use these exemplars as a comparison when marking student answers.

Question	Answers	Additional comments/Guidelines	Mark
01.1	B/ Boron **any 2 from:** protons in the centre of the atom/nucleus electrons are in shells/energy levels (around the nucleus) neutrons in the centre of the atom/nucleus most of the atom is empty space/most of mass in nucleus		3 (3 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
01.2	**Definition** <u>Average / mean mass of 1 atom (of an element)</u> (1) 1/12 mass of one atom of ^{12}C (1) Or <u>Average / mean mass of atoms of an element</u> 1/12 mass of one atom of ^{12}C		

01.2 (cont)	Or $\frac{\text{Average / mean mass of atoms of an element} \times 12}{\text{mass of one atom of } ^{12}\text{C}}$ Or $\frac{\text{(Average) mass of one mole of atoms}}{\text{1/12 mass of one mole of } ^{12}\text{C}}$ Or $\frac{\text{(Weighted) average mass of all the isotopes}}{\text{1/12 mass of one atom of } ^{12}\text{C}}$ Or Average mass of an atom/isotope compared to/relative to C−12 on a scale in which an atom of C−12 has a mass of 12 **Justification** Tellurium has Z = 52 but iodine has Z = 53 Or Te has **one** fewer proton than I / I has **one** more proton Or Tellurium has 6 outer shell electrons/valence electrons but iodine has 7 Or Te has similar chemistry/chemical properties to other Group 6 elements		3 (2 x AO1, 1 x AO3)

	Or I has similar chemistry/chemical properties to other Group 7 elements		

Question	Answers	Additional comments/Guidelines	Mark
01.3	$Te(g) + e^- \rightarrow Te^+(g) + 2e^-$ Or $Te(g) \rightarrow Te^+(g) + e^-$		1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
01.4	M1 $v = \frac{d}{t} = 4.17 \times 10^6$ (m s^{-1}) M2 $m = \frac{2KE \times t^2}{d^2}$ or $m = \frac{2KE}{v^2}$ or $\frac{2 \times 1.88 \times 10^{-12}}{(4.17 \times 10^6)^2}$ M3 m = 2.16×10^{-25} to 2.17×10^{-25} (kg) M4 mass of 1 mole of ions = $L \times 1000 \times$ M3 = 130.4 (g) M5 y = 130 or 131	M4 Allow 130 to 131 (3 or more significant figures) M5 Must be an integer	5 (4 x AO2, 1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
01.5	The *KE* of $^{126}Te^+$ is the same as the *KE* of $^{124}Te^+$		1 (1 x AO1)

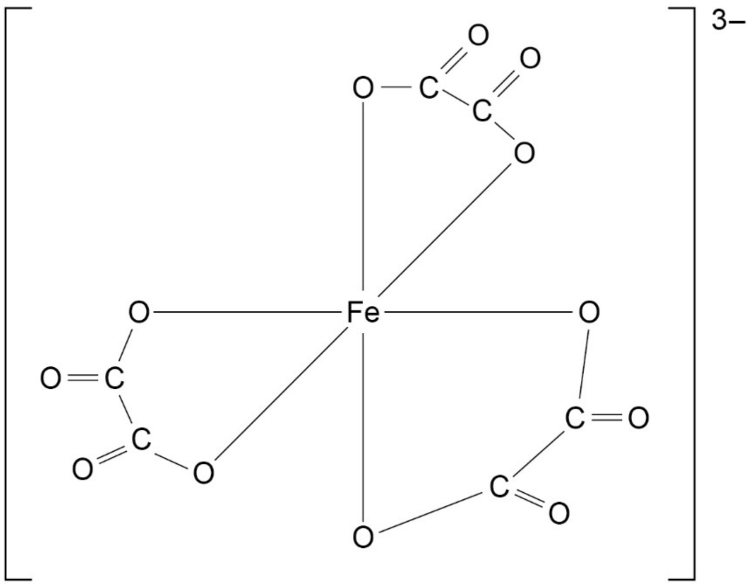
Question	Answers	Additional comments/Guidelines	Mark
02.1	(To make sure that) as much as possible/maximum amount (of solid) dissolves OR (To ensure that) the solution/it is saturated	Do not accept reacted Ignore references to right/correct concentration	1 (1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
02.2	Otherwise, the titre would be larger Or Would need a larger volume of acid/HCl Or Because undissolved strontium hydroxide will react (with the acid/HCl)	Allow (solid) could block pipette Ignore references to changes in concentration and pH	1 (1 x AO3)

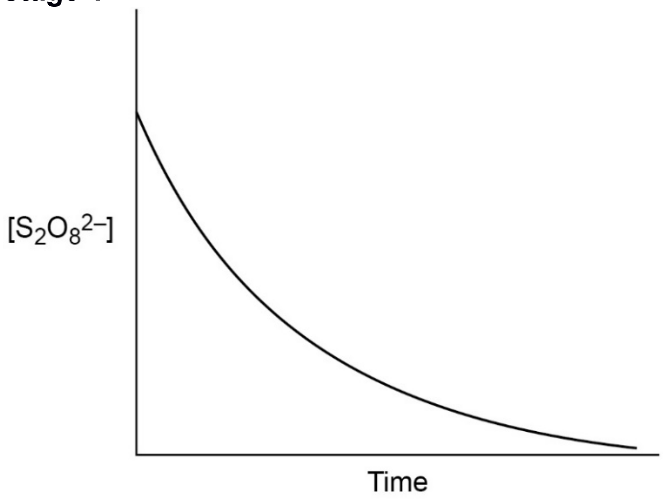
Question	Answers	Additional comments/Guidelines	Mark
02.3	To prevent reaction with carbon dioxide (in the air) OR To prevent evaporation (of water/from solution)	Allow so flask can inverted/shaken (to ensure homogeneous mixture) Ignore contamination	1 (1 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
02.4	Answer **C**		1 (1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
02.5	M1 $Sr(OH)_2 + 2HCl \rightarrow SrCl_2 + 2H_2O$ M2 32.43 (cm^3) M3 n HCl in mean titre = 3.24(3) × 10^{-3} mol M4 n $Sr(OH)_2$ in 25 cm^3 = 1.62 × 10^{-3} mol M5 n $Sr(OH)_2$ in 100 cm^3 of solution = 6.48 × 10^{-3} mol M6 mass = (6.48×10^{-3} mol x 121.6) = 0.788 (g per 100 cm^3 solution)	M1 Equation M2 allow 32.425 M3 allow 0.1 x M2 ÷ 1000 M4 allow M3 ÷ 2 M5 allow M4 × 4 M6 allow = M5 × 121.6 M6 allow 0.79 allow M5 and M6 in either order	6 (6 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
03.1		M1: 1 mark for structure Allow skeletal M2: 1 mark for charge of 3^{-} Ignore charges inside bracket	2 (2 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
03.2	M1 When bidentate/multidentate ligands replace monodentate ligands (to form a more stable complex) M2 Because there is an increase in entropy/positive entropy change/disorder or more particles formed (so ΔG is negative and ΔH is approximately 0)	M2 Allow S increases or ΔS is positive. Do not accept ΔS increases or S is positive	2 (2 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
03.3	This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question. **Level 3** **5–6 marks** All stages are covered and the description of each stage is generally correct and virtually complete. Answer is communicated coherently and shows a logical progression from stage 1 to stage 2 and stage 3. **Level 2** **3–4 marks** All stages are covered but the description of each stage may be incomplete or may contain inaccuracies OR two stages are covered and the explanations are generally correct and virtually complete. Answer is mainly coherent and shows progression from stage 1 to stage 2 and/or stage 3. **Level 1** **1–2 marks** Two stages are covered but the description of each stage may be incomplete or may contain inaccuracies, OR only one stage is covered but the explanation is generally correct and virtually complete. Answer includes isolated statements and these are presented in a logical order. **Level 0** **0 marks** Insufficient correct chemistry to gain a mark.	**Indicative Chemistry Content** **stage 1**  1a labelled axes **and** concentration (of $S_2O_8^{2-}$ ions) decreasing with time (ignore units) 1b downwards curve of reducing steepness	6 (2 × AO1, 2 x AO2, 2 x AO3)

		stage 2 explanation 2a (reaction slow) because $S_2O_8^{2-}$ and I^- repel/high Ea Or (reaction slow) because two negative ions repel/high Ea 2b Fe^{2+} attracts the $S_2O_8^{2-}$ so lower E_a Or Fe^{2+} and $S_2O_8^{2-}$ oppositely charged so lower Ea 2c Iron/Fe has a variable oxidation state Or Fe^{2+} oxidised to Fe^{3+} Or $Fe^{2+} \rightarrow Fe^{3+} + e^-$ **stage 3 equations** 3a $2Fe^{2+} + S_2O_8^{2-} \rightarrow 2SO_4^{2-} + 2Fe^{3+}$ 3b $2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$ 3c $S_2O_8^{2-} + 2I^- \rightarrow 2SO_4^{2-} + I_2$ allow equations with hexaaqua ions	

Question	Answers	Additional comments/Guidelines	Mark
03.4	$[Fe(H_2O)_4(OH)_2]$		1 (1 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
03.5	green precipitate $[Fe(H_2O)_6]^{2+} + Na_2CO_3 \rightarrow FeCO_3 + 6H_2O + 2Na^+$ Or $[Fe(H_2O)_6]^{2+} + CO_3^{2-} \rightarrow FeCO_3 + 6H_2O$	ignore state symbols	2 (1 × AO1, 1 × AO2)

Question	Answers	Additional comments/Guidelines	Mark
03.6	$2[Fe(H_2O)_6]^{3+} + 3\ Na_2CO_3 \rightarrow 2\ [Fe(H_2O)_3(OH)_3] + 3\ CO_2 + 3\ H_2O + 6Na^+$ Or $2\ [Fe(H_2O)_6]^{3+} + 3\ CO_3^{2-} \rightarrow 2\ [Fe(H_2O)_3(OH)_3] + 3\ CO_2 + 3\ H_2O$	ignore state symbols	1 (1 × AO3)

Question	Answers	Additional comments/Guidelines	Mark
04.1	Total amount of gas at equilibrium = 4.00 mol Mole fraction of H_2 = 0.23	Accept fractions	2 (2 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
04.2	(The amount in) moles of products is the same as reactants (so the units (of partial pressure) cancel out)	Allow equal moles/molecules/particles on both sides (so units cancel)	1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
04.3	The amount decreases.		1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
04.4	M1 $K_p = \frac{p(CH_3CH_2OH)}{p(C_2H_4)\,p(H_2O)}$ M2 = $\frac{0.0321 \times 6000}{(0.645 \text{ x } 6000) \times (0.323 \times 6000)} = \frac{192.6}{3870 \text{ x } 1938}$ M3 $K_p = 2.56 \times 10^{-5}$ M4 kPa^{-1}	M1 allow p or pp for partial pressure; round brackets not necessary BUT penalise square brackets. M2 allow correct use of 6000 to calculate partial pressure M3 Allow 2.57×10^{-5}	4 (4 x AO2)

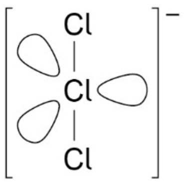
Question	Answers	Additional comments/Guidelines	Mark
04.5	no effect		1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
05.1	$Cl_2 + H_2O \rightleftharpoons HCl + HOCl$ Or $2Cl_2 + 2H_2O \rightarrow 4HCl + O_2$	allow → allow multiples	1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
05.2	$Cl_2 + 2NaOH \rightarrow NaCl + NaOCl + H_2O$	allow multiples	1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
05.3	M1 $2Cl^- \rightarrow Cl_2 + 2e^-$ M2 $2ClO_3^- + 12H^+ + 10e^- \rightarrow Cl_2 + 6H_2O$ M3 $2ClO_3^- + 12H^+ + 10Cl^- \rightarrow 6Cl_2 + 6H_2O$	allow multiples M3 allow $ClO_3^- + 6H^+ + 5Cl^- \rightarrow 3Cl_2 + 3H_2O$	3 (3 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
05.4	$NaCl + H_2SO_4 \longrightarrow HCl + NaHSO_4$ or $2NaCl + H_2SO_4 \longrightarrow 2HCl + Na_2SO_4$ base/proton acceptor		2 (1 × AO1, 1 × AO3)

Question	Answers	Additional comments/Guidelines	Mark
05.5		Ignore absence of minus sign	1 (1 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
05.6	180° (2) <u>bond pairs</u> repel to be as far apart as possible	allow (2) bond pairs repel equally ignore linear	2 (1 x AO2, 1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
06.1	M1 $E^{\ominus}$ V^{3+} (/V^{2+}) > $E^{\ominus}$ Zn^{2+} (/ Zn) Or EMF of reaction between V^{3+} and Zn = (+)0.50 V M2 $E^{\ominus}$ V^{2+}(/V) < $E^{\ominus}$ Zn^{2+} (/ Zn) Or EMF of reaction between V^{2+} and Zn = – 0.44 V		2 (2 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
06.2	Mg	only	1 (1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
06.3	EMF = (+) 0.78 (V) Fe(s) I Fe^{2+}(aq) II VO^{2+}(aq), H^+(aq), V^{3+}(aq) I Pt(s) Fe(s) → Fe^{2+}(aq) + 2 e^-	Allow Fe(s) I Fe^{2+}(aq) II VO^{2+}(aq), V^{3+}(aq) I Pt(s) Ignore state symbols Ignore state symbols	3 (1 × AO1, 2 × AO2)

Question	Answers	Additional comments/Guidelines	Mark
06.4	M1 n MnO_4^- = 29.43 × 10^{-3} × 0.0200 = 5.89 × 10^{-4} mol M2 n V^{2+} = 5.89 x 10^{-4} × $\frac{5}{3}$ = 9.81 × 10^{-4} mol M3 mass NH_4VO_3 = 9.81 × 10^{-4} × 116.9 = 0.1147 g M4 % purity = $\frac{0.1147 \times 100}{0.151}$ = 76.0 %	M2 = M1 × $\frac{5}{3}$ M3 = M2 × 116.9 M4 = M3 × $\frac{100}{0.151}$ allow 75.9 or 76.2 % answer to 3 significant figures	4 (4 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
07.1	M1 $K_w = [H^+][OH^-]$ M2 $[H^+] = \sqrt{2.92 \times 10^{-14}}$ M3 pH = 6.77	M3 = $-\log_{10}$ M2 answer to 2 decimal places	3 (1 × AO1, 2 × AO2)

Question	Answers	Additional comments/Guidelines	Mark
07.2	M1 n OH^- = 5.25 × 10^{-3} **and** n H^+ = 2.00 × 10^{-3} mol M2 excess OH^- = 3.25 × 10^{-3} mol M3 $[OH^-] = \frac{3.25\times10^{-3}}{55.0\times10^{-3}}$ = 0.0591 mol dm^{-3} M4 $[H^+] = \frac{2.92\times10^{-14}}{0.0591}$ = 4.94 × 10^{-13} mol dm^{-3} M5 12.31	M2 = n(OH^-) – n(H^+) in M1 M3 = $\frac{M2}{55\ x\ 10^{-3}}$ M4 = $\frac{2.92\ x\ 10^{-14}}{M3}$ M5 = $-\log_{10}$(M4)	5 (5 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
08.1	(Ions are) point charges Or (Ions are) perfect spheres Or No covalent character	Do not accept atoms or molecules in answer Allow no polarisation of ions	1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
08.2	$2\ Na^{+}(g)\ +\ 2e^{-}\ +\ O(g)$ $2\ Na(s)\ +\ \frac{1}{2}O_2(g)$		2 (2 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
08.3	–416 + x = 248 + (2 × 109) + (2 × 494) – 142 + 844 enthalpy of lattice dissociation = (+) 2572 (kJ mol^{-1})	–2572 (kJ mol^{-1}) scores 1 mark	2 (2 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
08.4	O^- repels the electron (being added)	Allow negative ion repels electron	1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
08.5	Oxide ions M1 have higher (negative) charge Or smaller size Or higher charge density/higher charge:size ratio (than chloride ions) M2 strong<u>er</u> attraction between (O^{2-} and Na^+/oppositely charged) ions	Ignore electronegativity	2 (2 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
08.6	enthalpy of solution = 771 – 406 – 364 = (+)1 (kJ mol^{-1})	Allow 1 mark for -1 ($kJmol^{-1}$)	2 (2 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
08.7	It reacts with water Or It reacts to form (a solution of) NaOH	Do not accept – It dissolves in water	1 (1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
08.8	M1 T = $\Delta H/\Delta S$ M2 T = $\frac{411}{90.1\times10^{-3}}$ = 4562 (K) M3 T = 4562 – 273 = 4289 (°C)	M3 = M2 – 273 M3: Allow 4290 (°C)	3 (1 x AO1, 2 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
09.1	more shells Or more energy levels	Allow Ca has 4 shells and Mg has 3 shells Do not accept more outer shells Ignore shielding Ignore subshells/orbitals/more electrons	1 (1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
09.2	$Mg(s) + H_2O(g) \longrightarrow MgO(s) + H_2(g)$	State symbols required Allow multiples	1 (1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
09.3	M1 (Ba is more reactive) because <u>outer/valence</u> electrons further from nucleus/less attracted to the nucleus/lost more easily M2 Insoluble barium sulfate (is formed) Or $Ba + H_2SO_4 \rightarrow BaSO_4(s) + H_2$ M3 Barium sulfate prevents further reaction (with sulfuric acid) Or Barium gets coated with barium sulfate (so no more barium reacts)		3 (2 x AO1, 1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
09.4	M1 P = 100 000 Pa and V = 348×10^{-6} m^3 M2 n = $\frac{PV}{RT}$ or $\frac{100\ 000\ x\ 348\ x\ 10^{-6}}{8.31\ x\ 298}$ M3 n = 0.01405 mol M4 n metal nitrate = 0.01405 × $\frac{2}{5}$ = 5.62×10^{-3} mol M5 M_r metal nitrate = $\frac{0.832}{5.62 \times 10^{-3}}$ = 148(.0) M6 A_r of metal = 148.0 – (2 × 14 +2 × 48) = 24(.0) = Mg	M4 = M3 x $\frac{2}{5}$ M5 = 0.832 ÷ M4 M6 = M5 – 124 **and** identity of a metal with 2+ oxidation state	6 (1 x AO1, 5 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
09.5	M1 Na + Al + 2 H_2 → $NaAlH_4$ M2 contains oppositely charged ions/ Na^+ and AlH_4^- ions M3 strong attraction between (oppositely charged) ions		3 (2 x AO2, 1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
09.6	$3\ NaOH + H_3PO_4 \rightarrow Na_3PO_4 + 3\,H_2O$	Allow multiples and ignore state symbols	1 (1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
09.7	$Li^{+} + CoO_2 + e^{-} \rightarrow Li^{+}(CoO_2)^{-}$	allow $Li(CoO_2)$ as product	1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
09.8	The electrode reactions can be reversed (by applying a reverse potential)	Allow reaction is reversible (by applying a reverse potential)	1 (1 x AO1)