AQA

A-level
CHEMISTRY
7405/1

Paper 1 Inorganic and Physical Chemistry

Mark scheme

June 2023

Version: 1.0 Final

236A74051/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.

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 <u>not</u> 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.

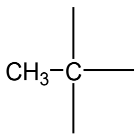
3.12 Organic structures

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.

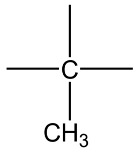
In general

- 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.

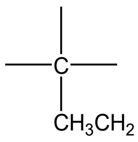
By way of illustration, the following would apply.



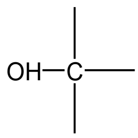
allowed



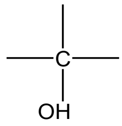
allowed



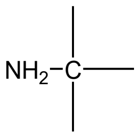
not allowed



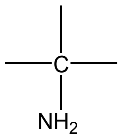
not allowed



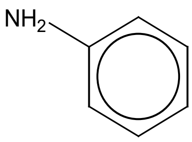
not allowed



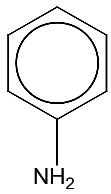
allowed



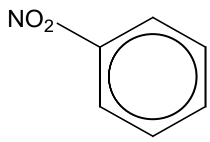
allowed



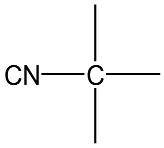
allowed



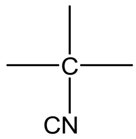
allowed



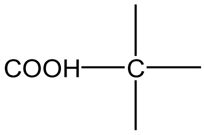
not allowed



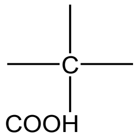
not allowed



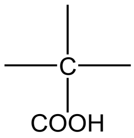
not allowed



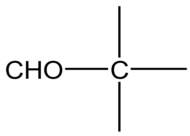
not allowed



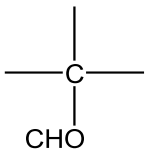
not allowed



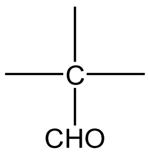
not allowed



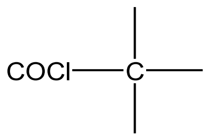
not allowed



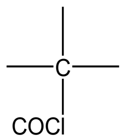
not allowed



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.

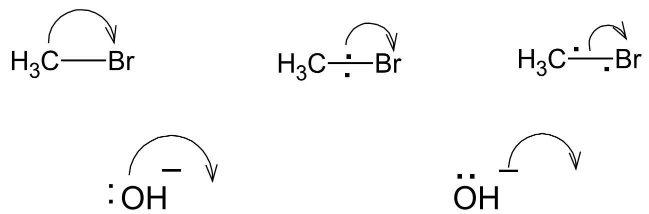
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

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**

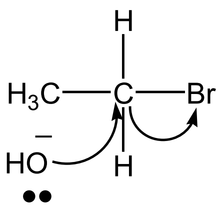
3.14 Organic reaction mechanisms

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.

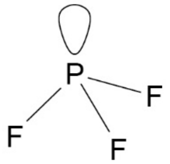
An answer which contains nothing of relevance to the question must be awarded no marks.

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.

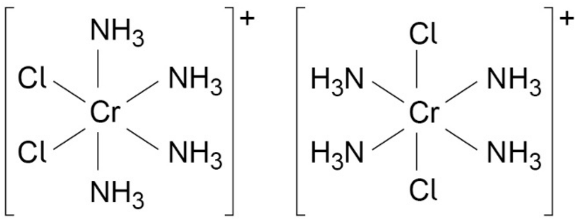
Question	Answers	Additional comments/Guidelines	Mark
01.1	(Central) metal atom/ion surrounded by ligands	Allow complex in which number of coordinate bonds exceeds oxidation state of the metal	1 (AO1)

Question	Answers	Additional comments/Guidelines	Mark
01.2	 Pyramidal or tetrahedral	Allow diagram with 3 bonds <u>and</u> 1 lone pair Allow triangular pyramid	2 (1 x AO1, 1 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
01.3	PF_3 is neutral **and** the complex is neutral	Allow PF_3 has no charge **and** the complex has no charge Ignore electronegativity	1 (AO3)

Question	Answers	Additional comments/Guidelines	Mark
01.4	(+)3		1 (AO3)

01.5	Covalent (bond)		1 (AO3)

Question	Answers	Additional comments/Guidelines	Mark
01.6	 Cis-trans/geometric/E-Z isomerism	M1 for the two isomers M2 for the charge on the complex ion. Allow 1 mark for one correct isomer with + charge Ignore stereoisomerism	3 (3 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
01.7	$[Cr(H_2O)_5Cl]Cl_2$	Allow $[Cr(H_2O)_5Cl]^{2+}$ + 2 Cl^-	1 (AO3)

Question	Answers	Additional comments/Guidelines	Mark
02.1	Allow to complete the circuit Or Allow ions to move (between half cells) Potassium/sodium nitrate or any soluble ionic compound that does not react with H^+ or magnesium ions or chloride ions	Allow to maintain electrical neutrality Do not accept electrons flowing Allow any soluble ionic compound that does not react with acid or magnesium ions or chloride ions	2 (2 x AO1)

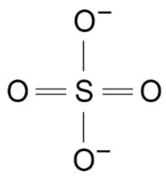
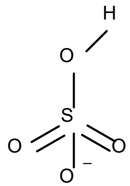
Question	Answers	Additional comments/Guidelines	Mark
02.2	No change		1 (AO1)

Question	Answers	Additional comments/Guidelines	Mark
02.3	EMF increases		1 (AO3)

Question	Answers	Additional comments/Guidelines	Mark
02.4	$Mg + 2HCl \rightarrow MgCl_2 + H_2$	Allow $Mg + 2H^+ \rightarrow Mg^{2+} + H_2$ Ignore state symbols allow multiples	1 (AO3)

Question	Answers	Additional comments/Guidelines	Mark
03.1	$P_4 + 5\,O_2 \rightarrow P_4O_{10}$	Allow $4\,P + 5\,O_2 \rightarrow P_4O_{10}$	1 (AO1)

Question	Answers	Additional comments/Guidelines	Mark
03.2	$SO_2 + H_2O \rightarrow H_2SO_3$ Or $SO_2 + H_2O \rightarrow 2\,H^+ + SO_3^{2-}$ Or $SO_2 + H_2O \rightarrow H^+ + HSO_3^-$	Do not accept H_2SO_4	1 (AO1)

Question	Answers	Additional comments/Guidelines	Mark
03.3		Allow 	1 (AO1)

Question	Answers	Additional comments/Guidelines	Mark
03.4	**M1** $Mg + H_2O \rightarrow MgO + H_2$ **M2** White solid/white powder **OR** **(**Bright) white light/white flame	Do not accept white ppt Do not accept effervescence	2 (2 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
03.5	$3\ MgO + 2\ H_3PO_4 \rightarrow Mg_3(PO_4)_2 + 3\ H_2O$	Allow $3\ MgO + 2\ H_3PO_4 \rightarrow 3\ Mg^{2+} + 2\ PO_4^{3-} + 3\ H_2O$	1 (AO1)

Question	Answers	Additional comments/Guidelines	Mark
04.1	M1 0.176 M2 0.549 M3 0.275	Allow answers to 2 significant figures	3 (3 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
04.2	21.1 (kPa)	Allow answer to question **04.1** x 120 and answer in kPa Allow 21.6 (kPa) Answer using given value of 0.380 mol = 45.6(kPa)	1 (AO2)

Question	Answers	Additional comments/Guidelines	Mark
04.3	M1 $K_p = \frac{p(NO)^2 p(O_2)}{p(NO_2)^2}$ M2 $= \frac{K_p \times \text{mol frac } (NO_2)^2}{\text{mol frac } (NO)^2 \times \text{mol frac } (O_2)}$ OR $\frac{59.7 \times (0.31)^2}{(0.46)^2 \times (0.23)}$ M3 = 117.9 (kPa) or 118 (kPa)	Do **not** allow square brackets Rearrangement	3 (1 x AO1, 2 x AO2)

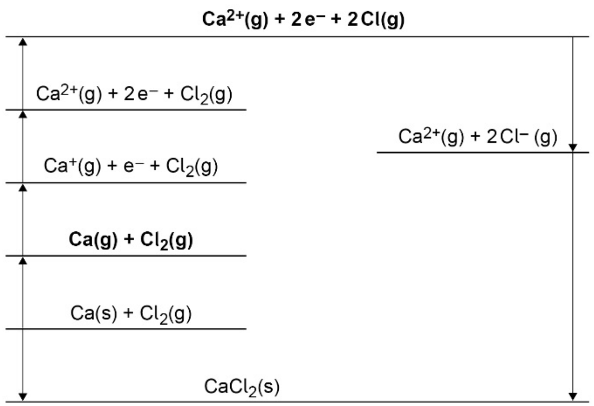
Question	Answers	Additional comments/Guidelines	Mark
04.4	Decrease No change		2 (1 x AO1, 1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
04.5	M1 Reaction is endothermic OR exothermic in backwards direction M2 Equilibrium shifts/moves in backwards direction/to the left to raise the temp/oppose the decrease in temp		2 (2 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
05.1	(Enthalpy change = lattice dissociation energy + hydration energies of ions) M1 Enthalpy change = **+**2237 – (**2** x 364) – 1650 M2 = – 141 kJ mol^{-1}		2 (2 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
05.2	Temperature goes up/increases	Allow answer consequential on 05.1	1 (AO3)

Question	Answers	Additional comments/Guidelines	Mark
05.3	M1 fluoride ions/F^- (ions) are smaller OR M1 F^- has a higher charge density M2 stronger <u>attraction</u> (of fluoride ion) to δ+ on H/ electron deficient H (in water)	Do not accept fluorine atoms/ions are smaller M2 do not accept ionic bonds Do not accept more energy to break bonds Do not accept stronger attraction to H^+ Ignore electronegativity and shielding	2 (2 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
05.4			2 (2 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
05.5	–795 = 193 + 590 + 2nd IE + (121 **x 2**) + (–364 **x 2**) –2237 = (+) 1145 (kJ mol^{-1})	M1: Allow -795 = -1940 + 2nd IE	2 (2 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
05.6	Electron removed from a positive charge/ion OR Electron removed from smaller ion/electron removed closer to nucleus OR Stronger attraction between same number of protons and fewer electrons		1 (AO3)

Question	Marking Guidance		Additional Comments/Guidelines	Mark
05.7	This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.		**Stage 1 comparing values from perfect ionic model** **1a** Value for $CaCl_2$ is larger OR Values for KCl **and** AgCl are similar OR Values for $CaCl_2$ > AgCl > KCl **1b** Ca^{2+} has a larger charge/ is a smaller ion OR Ag^+ **and** K^+ have smaller charge or larger ions **1c** $CaCl_2$ has stronger ionic bonds or stronger attraction between + and – ions ($Ca^{2+}$and Cl^-) OR AgCl **and** KCl have weaker ionic bonds or weaker attraction between + and – ions (Ag^+/ K^+ and Cl^-) **Stage 2 similarities in the perfect ionic model and Born-Haber cycle values** **2a** $CaCl_2$ has similar values (between the perfect ionic model and Born-Haber cycle) **2b** KCl has similar values (between the perfect ionic model and Born-Haber cycle) **2c** $CaCl_2$ **and** KCl have (almost) perfect ionic bonding or + ions are point charges/(perfectly) spherical **Stage 3 difference in the perfect ionic model and Born-Haber cycle values** **3a** AgCl has larger difference in values (between the perfect ionic model and Born-Haber cycle) **3b** AgCl contains (some) covalent character **3c** Ag^+ more polarising/distorts electron cloud more	6 (2 x AO1, 2 x AO2, 2 x AO3)
	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 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 is generally correct and virtually complete** Answer includes isolated statements and these are presented in a logical order.		
	0 marks	Insufficient correct chemistry to gain a mark.		

Question	Answers	Additional comments/Guidelines	Mark
06.1	$\frac{0.100 \times 250 \times 171.3}{1000} = 4.28$ g	Allow 4.3 g	1 (AO2)

Question	Answers	Additional comments/Guidelines	Mark
06.2	M1 Transfers the solution to a <u>volumetric/graduated</u> flask M2 Add <u>washings</u> using <u>distilled</u> water and make up to the graduation mark/250 cm^3 M3 Invert many times / shake to mix		3 (3 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
06.3	So that the titration is done with known concentration of $Ba(OH)_2$	Allow so that water does not dilute the solution Allow remove water/prevent contamination	1 (AO3)

Question	Answers	Additional comments/Guidelines	Mark
06.4	Drops of acid could fall into the burette (so no longer know how much has been added from burette) OR Decreases titre	Ignore changes the titre Do not accept increases titre	1 (AO1)

Question	Answers	Additional comments/Guidelines	Mark
06.5	**M1** n $Ba(OH)_2$ in 25 cm^3 = $\frac{0.952}{171.3 \textbf{ x10}}$ = 5.56 x 10^{-4} mol **M2** n HCl in 24.5 cm^3 = **2 x** 5.56 x 10^{-4} = 0.00111 mol **M3** Concentration of HCl = $\frac{0.00111 \times 1000}{24.50}$ = 0.045 mol dm^{-3}	M2 = M1 x 2 M3 = $\frac{\text{M2} \times 1000}{24.50}$	3 (3 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
06.6	$\left(\frac{0.15}{24.50} + \frac{0.05}{25.00}\right)$ x 100% = 0.8(1)%		1 (AO2)

Question	Answers	Additional comments/Guidelines	Mark
07.1	$1s^2\ 2s^2\ 2p^6$	Allow [He] $2s^22p^6$	1 (AO1)

Question	Answers	Additional comments/Guidelines	Mark
07.2	$Al_2(SO_4)_3 + 12\ H_2O \rightarrow 2\ [Al(H_2O)_6]^{3+} + 3\ SO_4^{2-}$	Allow $[Al(H_2O)_6]_2(SO_4)_3$	1 (AO1)

Question	Answers	Additional comments/Guidelines	Mark
07.3	**M1** Al^{3+} has a high charge **and** small size OR Al^{3+} has a high charge density **M2** Al^{3+} weakens the O-H bond (in water ligands and donates H^+ to water or forms H_3O^+ ions with water)	**M2** Al^{3+} attracts electrons from the O-H bond (in the ligand and releases H^+ or H_3O^+ ions) OR Al^{3+} polarises the O-H bond/water molecule	2 (2 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
07.4	Colourless (solution)	Allow no d-d transitions (as there are no d electrons) OR Doesn't absorb visible light	1 (AO3)

Question	Answers	Additional comments/Guidelines	Mark
07.5	$[Al(H_2O)_6]^{3+} + 3\,NH_3 \rightarrow Al(H_2O)_3(OH)_3 + 3\,NH_4^+$ White ppt or white solid	Do **not** accept effervescence Do **not** accept white ppt dissolves in excess NH_3 Ignore state symbols	2 (1 x AO1, 1 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
07.6	$[Al(H_2O)_6]^{3+}$		1 (AO3)

Question	Answers	Additional comments/Guidelines	Mark
07.7	A circle around one or more N A circle around one or more O^-		2 (2 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
07.8	M1 n ($EDTA^{4-}$) added = <u>5×10^{-4}</u> mol M2 n (Zn^{2+}) = <u>1.89×10^{-4}</u> mol M3 n ($EDTA^{4-}$) reacted with the 25 cm^3 sample of Al^{3+} = $5 \times 10^{-4} - 1.89 \times 10^{-4} = 3.11 \times 10^{-4}$ mol M4 n $EDTA^{4-}$ reacted with the 250 cm^3 sample of Al^{3+} = 3.11×10^{-4} **x 10** = 3.11×10^{-3} mol M5 n $Al_2(SO_4)_3\,xH_2O$ = 3.11×10^{-3} **÷ 2** = 1.555×10^{-3} mol M6 M_r $Al_2(SO_4)_3\,xH_2O$ = $1.036 \div 1.555 \times 10^{-3}$ = 666.2 M7 342.3 + 18 x = 666(.2) so x = 18	alternative methods will be allowed M3 = M1 – M2 M4 = $\frac{M3 \times 250}{25}$ M5 = M4 ÷ 2 M6 = 1.036 ÷ M5 M7 = $\frac{M6 - 342.3}{18}$ and answer as integer	7 (7 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
08.1	$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$		1 (AO1)

Question	Answers	Additional comments/Guidelines	Mark
08.2	$CH_3OH + H_2O \rightarrow CO_2 + 6H^+ + 6e^-$		1 (AO2)

Question	Answers	Additional comments/Guidelines	Mark
08.3	1.23 (V)		1 (AO2)

Question	Answers	Additional comments/Guidelines	Mark
08.4	Reactants supplied continuously	Allow fuel continuously supplied Allow continuous supply of chemicals	1 (AO1)

Question	Answers	Additional comments/Guidelines	Mark
08.5	Methanol (is liquid so) can be stored easily or transported easily	More energy can be produced from 1 cm^3 of methanol (liquid) than from 1 cm^3 of hydrogen (gas) Ignore references to safety and cost Do not accept no greenhouse gas emissions	1 (AO2)

Question	Answers	Additional comments/Guidelines	Mark
09.1	$Sr(g) + e^- \rightarrow Sr^+(g) + 2e^-$	Allow $Sr(g) \rightarrow Sr^+(g) + e^-$	1 (AO1)

Question	Answers	Additional comments/Guidelines	Mark
09.2	M1 V = (d÷t =) $0.950 \div 9.47 \times 10^{-4}$ OR 1003 m s^{-1} M2 $m = \frac{2KE}{v^2}$ or $\frac{2 \times 7.02 \times 10^{-20}}{1003^2}$ (= 1.396×10^{-25} kg) M3 mass of ion = 1.396×10^{-22} (g) M4 mass of one mol of ions in g = $1.396 \times 10^{-22} \times 6.022 \times 10^{23}$ (= 84.04) M5 mass number = 84	Recall and conversion of d into metres Allow $\frac{2 \times 7.02 \times 10^{-20}}{M1^2}$ or $\frac{2KE\,t^2}{d^2}$ M3 = M2 x1000 M4 = M3 x Avogadro's number Conversion to g may be seen in M4 Answer as whole number	5 (1 x AO1, 4 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
09.3	**M1** (Ions hit a detector/electron multiplier and) each ion gains an electron (generating a current) **M2** current is proportional to abundance		2 (2 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
09.4	**M1** Abundance ^{87}Sr = 2 × 18 ÷ 3 = 12(%) **M2** $A_r = \frac{(82 \times 88) + (12 \times 87) + (6 \times 86)}{100}$ **M3** = 87.8	Answer to 1 decimal place	3 (2 x AO2, 1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
09.5	the protein (ion) does not break up/fragment		1 (AO3)

Question	Answers	Additional comments/Guidelines	Mark
10.1	Thymol blue		1 (AO3)

Question	Answers	Additional comments/Guidelines	Mark
10.2	$K_a = \frac{[H^+][CH_3CH_2COO^-]}{[CH_3CH_2COOH]}$	Square brackets essential	1 (AO1)

Question	Answers	Additional comments/Guidelines	Mark
10.3	**M1** $K_a = 10^{-pK_a} = 1.35 \times 10^{-5}$ **M2** $K_a = \frac{[H^+]^2}{[CH_3CH_2COOH]}$ OR $[H^+]^2 = K_a\,[CH_3CH_2COOH]$ **M3** $[H^+] = \sqrt{(1.35 \times 10^{-5} \times 0.1)} = 1.16 \times 10^{-3}$ mol dm^{-3} **M4** pH = $-\log_{10}(1.16 \times 10^{-3}) = 2.94$	M2 Square brackets or with numbers M4 = $-\log_{10}$ M3 Answer to 2 decimal places Allow 2.93	4 (4 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
10.4	**M1** Initial amount of butanoic acid = 25 × 0.1 ×10^{-3} = <u>2.5 ×10^{-3}</u> mol **M2** Initial amount of NaOH = 20 × 0.1 × 10^{-3} = <u>2.0 × 10^{-3}</u> mol **M3** Final amount of acid = 2.5 × 10^{-3} – 2.0 × 10^{-3} = 5.0 × 10^{-4} mol **M4** $[H^+] = \frac{K_a \times [HX]}{[X^-]}$ Or $[H^+] = \frac{1.51 \times 10^{-5} \times 0.0111}{0.0444}$ **M5** pH = 5.42	**M3** = M1-M2 **M4** allow volumes cancelled out $\frac{1.51 \times 10^{-5} \times 5.0 \times 10^{-4}}{2.0 \times 10^{-3}}$ **M4** Allow $[H^+]$ = 3.775 × 10^{-6} mol dm^{-3} Alternative method for **M4** pH = pKa + log $\frac{[X^-]}{[HX]}$ = 4.82 + log $\left(\frac{0.0444}{0.0111}\right)$ **M5** = dependent on a correct expression for $[H^+]$ in M4	5 (5 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
10.5	**M1** This is a weak acid and weak base/alkali titration **M2** pH change is too gradual/not sharp (at the equivalence point so colour change of indicator is difficult to judge)	**M2** Allow no vertical/steep section on pH curve	2 (2 x AO3)