A-level
CHEMISTRY
7405/1

Paper 1 Inorganic and Physical Chemistry

Mark scheme

June 2025

Version: 1.0 Final

256A7405/1/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

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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.

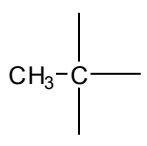
3.12 Organic structures

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.

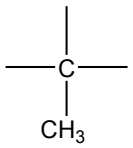
In general

- 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.

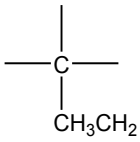
By way of illustration, the following would apply.



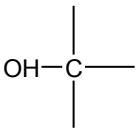
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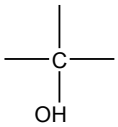
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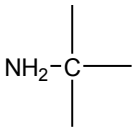
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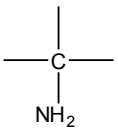
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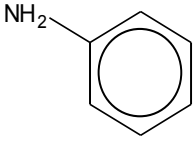
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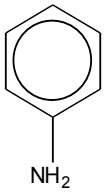
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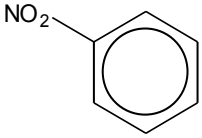
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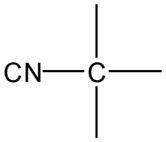
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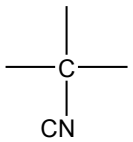
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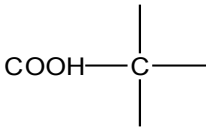
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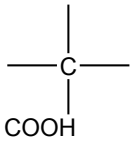
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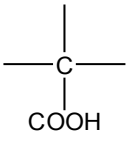
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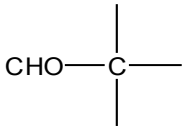
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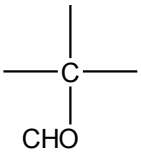
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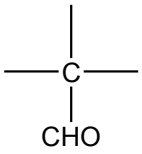
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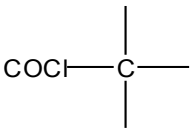
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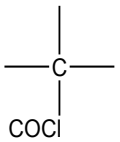
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- Representation of CH_2 by $C–H_2$ will be penalised
- Some examples are given here of **structures** for specific compounds that should **not** gain credit (but, exceptions **may** be made in the context of balancing equations)

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.

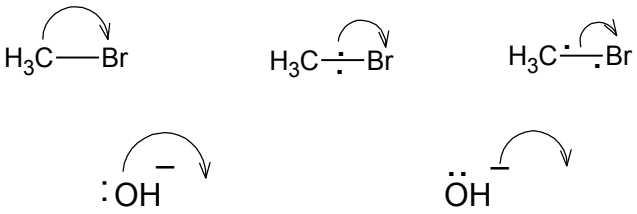
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

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**

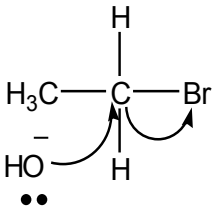
3.14 Organic reaction mechanisms

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	M1 $TiCl_4$ + **2** Mg → Ti + **2** $MgCl_2$ M2 reducing agent	M2 accept electron donor	2 (1 x AO1, 1 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
01.2	M1 $Ca(OH)_2$ M2 $CaCO_3$ or CaO		2 (2 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
01.3	magnesium hydroxide is insoluble/sparingly soluble/less soluble (than sodium hydroxide) OR magnesium hydroxide is less/not corrosive (but sodium hydroxide is corrosive)	Ignore references to base strength or pH	1 (1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
01.4	M1 Mg^{2+} M2 $Mg^{2+} + \mathbf{2}OH^- \rightarrow Mg(OH)_2$	M1 and M2 allow Ca^{2+} Ignore state symbols	2 (2 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
01.5	M1 Br^- / bromide M2 $Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$ M3 to remove carbonate ions OR to remove other ions that give a precipitate (with silver nitrate)	 Ignore other substances/impurities that interfere with the reaction	3 (1 x AO2, 2 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
01.6	Insoluble OR Shows up on/blocks/absorbs/scatters X-ray OR Radiopaque	Ignore barium meal if no qualification Ignore X-rays if no qualification	1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
02.1	M1 smallest atom/atomic radius OR smallest number of shells/energy levels OR outer electron is closest to the nucleus OR least shielding M2 strongest attraction between <u>outer/valence</u> electron(s) and nucleus	Allow comparative and superlative only for M1 and M2 Allow correct trends up or down Group 2	2 (2 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
02.2	$Be^{+}(g) \rightarrow Be^{2+}(g) + e^{-}$ OR $Be^{+}(g) + e^{-} \rightarrow Be^{2+}(g) + \mathbf{2}\ e^{-}$		1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
02.3	Mg/Magnesium		1 (1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
02.4	M1 P M2 large increase/jump from 5th to 6th ionisation energy/after 5th ionisation energy M3 the 6th electron is removed from the 2 (principal) energy level/from a lower energy level/from a lower shell/from 2p/from an energy level that is closer to the nucleus	Mark M1, M2 and M3 independently	3 (2 x AO1, 1 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
02.5	allow answer in range 2500–3200		1 (1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
03.1	1 or one		1 (1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
03.2	(Water) has a lone pair (of electrons on the O) that it can donate (to copper) Or (Water) has a lone pair (of electrons on the O) that forms a co-ordinate/dative covalent bond (to copper)	Allow lone pair donor/electron pair donor/both electrons	1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
03.3	M1 Blue-green/green-blue/green precipitate/solid M2 $[Cu(H_2O)_6]^{2+} + CO_3^{2-} \rightarrow CuCO_3 + \mathbf{6}\,H_2O$	M1 Do not accept blue M2 $[Cu(H_2O)_6]^{2+} + Na_2CO_3 \rightarrow CuCO_3 + 6\,H_2O + 2Na^+$ Ignore state symbols Allow multiples	2 (1 x AO1, 1 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
03.4	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.	**Stage 1** 1a Octahedral $[Cu(H_2O_6)]^{2+}$ (with 6 ligands) and tetrahedral $[CuCl_4]^{2-}$ (with 4 ligands) or diagram of both complexes 1b Cl^- ligands are bigger (so only 4 fit around the Cu^{2+}) or reverse argument **Stage 2** 2a d-orbitals split (into ground state and excited state) 2b (some wavelengths/frequencies) of white/visible light are absorbed (by the complex) 2c electrons are excited/promoted (from ground state to excited state) OR d–d transitions occur **Stage 3** 3a Different ligand/co-ordination number changes the energy gap/splitting OR octahedral and tetrahedral complexes have different energy gap/splitting (in the d orbitals) 3b The energy gap is related to the wavelength/frequency OR $\Delta E = h\nu$ OR ΔE = hf OR $\Delta E = hc \div \lambda$ 3c Wavelengths/frequencies/colour not absorbed are transmitted/reflected (not emitted) OR light reflected is complementary to light absorbed.	6 (2 x AO1, 2 x AO2, 2 x AO3)

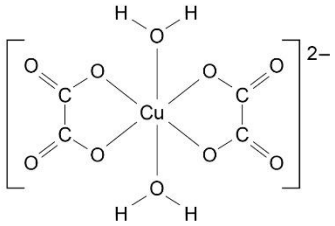
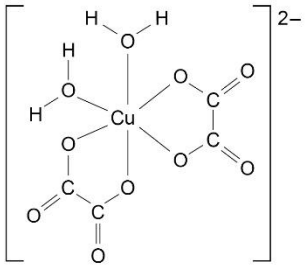
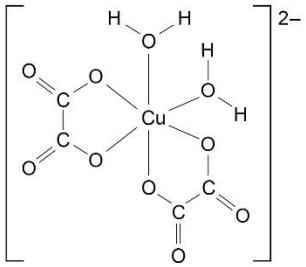
03.4 (cont)	**Level 0** **0 marks** Insufficient correct chemistry to gain a mark.		

Question	Answers	Additional comments/Guidelines	Mark
03.5	M1 (yellow solution turns to a) deep/dark blue solution M2 $[CuCl_4]^{2-}$ + **4** NH_3 + **2** H_2O → $[Cu(NH_3)_4(H_2O)_2]^{2+}$ + **4** Cl^-		2 (1 x AO1, 1 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
03.6	**2** MnO_4^- + **5** $C_2O_4^{2-}$ + **16** H^+ → **2** Mn^{2+} + **10** CO_2 + **8** H_2O	Allow multiples Ignore state symbols	1 (1 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
03.7	28.55 cm^3		1 (1 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
03.8	M1 n MnO_4^- = 28.55 × 10^{-3} × 0.0200 = 5.71 ×10^{-4} mol M2 n $C_2O_4^{2-}$ = M1 × $\frac{5}{2}$ M3 n $C_2O_4^{2-}$ in 250 cm^3 = M2 × 10 M4 n complex = $\frac{M3}{2}$ M5 M_r complex = $\frac{2.52}{M4}$ and answer on line M6 M_r of **2 M** = M5 – 275.5 M7 M_r of **M** = M6 ÷ 2 **and** metal with +1 oxidation state **and** answer on line	M1 n MnO_4^- = 28.55 × 10^{-3} × 0.0200 = 5.710 × 10^{-4} mol M2 n $C_2O_4^{2-}$ = 5.71 × 10^{-4} × $\frac{5}{2}$ = 1.4275 × 10^{-3} mol M3 n $C_2O_4^{2-}$ in 250 cm^3 = 1.4275 × 10^{-3} × 10 = 1.4275 ×10^{-2} mol M4 n complex = $\frac{1.4275 \times 10^{-2}}{2}$ = 7.1375 × 10^{-3} mol M5 M_r complex = $\frac{2.52}{7.1375 \times 10^{-3}}$ = 353 and answer on line If answer on line is not correct but final answer is correct lose M5 M6 M_r of **2 M** =353 – 275.5 = 77.5 M7 M_r of **M** = 38.8 so potassium / K on answer line M7 Allow K^+	7 (5 x AO2, 2 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
03.9	any 2 from these 3 structures    allow one mark for 2 structures with no charge shown	Ligands must be bonded via correct atoms 1 mark for structure 1 mark for 2- charge outside **both** brackets	2 (2 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
04.1	Standard pressure/100 kPa **and** a stated temperature/298 K	allow 1 bar do not accept 1 atm	1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
04.2	M1 $\Delta H^{\ominus}$ = (2 × –602) + (4 × 34) – (2 × –790) = 512 kJ mol^{-1} M2 $\Delta S^{\ominus}$ = (27 × 2) + (4 × 240) + 205 – (2 × 164) = 891 J K ^{1} mol^{-1} M3 $\Delta S^{\ominus}$ = 0.891 kJ K^{-1} mol^{-1} M4 T = $\frac{\Delta H}{\Delta S}$ M5 T = $\frac{512}{0.891}$ = 575 K	M3: ∆S divided by 1000 M3: Allow ∆H = 512 000 Jmol^{-1}	5 (1 x AO1, 4 x AO2)

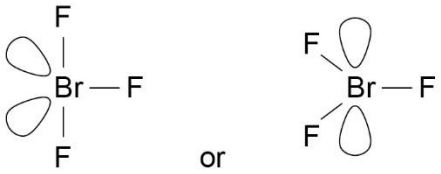
Question	Answers	Additional comments/Guidelines	Mark
04.3	M1 –1132 = (12 × 388) + (7 × 496) – (8 × N–O) – (12 × 463) M2 (8 N–O) = 3704 kJ mol^{-1} M3 BE N–O = 463 kJ mol^{-1}	M1 Allow 8x =8128-5556+1132 M3 = M2 ÷ 8 to give a positive value	3 (3 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
04.4	Heterogeneous		1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
04.5	M1 (forward) reaction is exothermic M2 equilibrium moves/shifts to lower the temperature OR equilibrium moves/shifts to oppose the increase in temperature	M1 reverse reaction is endothermic Ignore favours M2: Equilibrium moves/shifts to the left/backwards is insufficient	2 (1 x AO1, 1 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
05.1	M1 Chlorine smaller / fewer electrons / fewer shells / smaller M_r M2 The van der Waals/vdw forces between chlorine molecules are weaker/fewer (so less energy needed to separate the molecules)	"It" is chlorine Allow converse answers for bromine.	2 (2 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
05.2	Br (+)3, F –1	both needed for the mark	1 (1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
05.3	 M2 Lone pairs/bond pairs/electron pairs repel (each other to be) as far apart as possible. OR Lone pairs/bond pairs/electron pairs are arranged (to be) as far apart as possible to minimise repulsion.	Allow any shape with 3 bond pairs and 2 lone pairs of electrons	2 (1 x AO1, 1 x AO2)

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th></tr>
<tr><td>05.4</td><td>
<table>
<tr><td>M1: Acid-base equation</td><td>H_2SO_4 + NaBr → $NaHSO_4$ + HBr
OR
H_2SO_4 + 2 NaBr → Na_2SO_4 + 2 HBr</td></tr>
<tr><td>M2: Observation for acid- base reaction</td><td>white/misty/steamy fumes</td></tr>
<tr><td>M3: Redox equation</td><td>H_2SO_4 + 2 H^+ + 2 Br^- → SO_2 + Br_2 + 2 H_2O
OR
SO_4^{2-} + 4 H^+ + 2 Br^- → SO_2 + Br_2 + 2 H_2O
OR
H_2SO_4 + 2 HBr → SO_2 + Br_2 + 2 H_2O</td></tr>
<tr><td>M4: Observation for redox reaction</td><td>M4 orange/brown fumes/gas</td></tr>
</table>
</td><td>Mark M1 to M4 independently

M4 Allow choking gas</td><td>4
(4 x AO2)</td></tr>
</table>

Question	Answers	Additional comments/Guidelines	Mark
05.5	**2** Cu^{2+} + **4** I^- → **2** CuI + I_2		1 (1 x AO2)

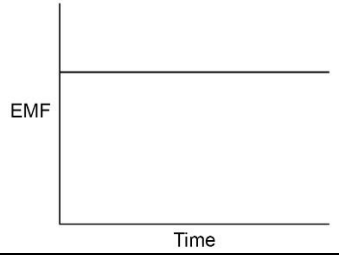
Question	Answers	Additional comments/Guidelines	Mark
06.1	Negative electrode $H_2 + \mathbf{2}OH^- \rightarrow \mathbf{2}H_2O + \mathbf{2}e^-$ Positive electrode $O_2 + \mathbf{2}H_2O + \mathbf{4}e^- \rightarrow \mathbf{4}OH^-$ award 1 mark if both equations correct but in wrong order	Accept multiples Ignore state symbols	2 (2 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
06.2	The OH^- ions are produced in one half equation/electrode and used in the other (half equation/electrode).		1 (1 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
06.3	M1 electrons released at the negative electrode M2 (electrons) pass through the motor/external circuit to the positive electrode	Allow M1 Hydrogen releases electrons/is oxidised M2 (electrons) pass through the motor/external circuit to oxygen (which is reduced)	2 (2 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
06.4	carbon dioxide/CO_2 (in the air would react with the electrolyte)		1 (1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
06.5	Occupies less volume	Allow minimises chance of escape Ignore cost/safety/transport	1 (1 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
06.6	C  		1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
06.7	same overall reaction/equation		1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
07.1	d (block)	Do not accept 3d	1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
07.2	layers of atoms can slide over one another	allow layers of (positive) ions can slide over one another	1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
07.3	M1 $V_2O_5 + SO_2 \rightarrow V_2O_4 + SO_3$ M2 $V_2O_4 + \frac{1}{2}O_2 \rightarrow V_2O_5$	allow multiples allow 1 mark for equations in wrong order	2 (2 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
07.4	M1 identification of V^{3+} as only vanadium product M2 $VO_2^+ + \mathbf{4}H^+ + Sn \rightarrow V^{3+} + Sn^{2+} + \mathbf{2}H_2O(l)$	Ignore state symbols	2 (2 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
07.5	M1 ions are V^{3+} and SO_4^{2-} OR contains oppositely charged ions M2 strong attraction between them		2 (2 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
07.6	M1 $V_2(SO_4)_3$ + **12** H_2O → **2** $[V(H_2O)_6]^{3+}$ + **3** SO_4^{2-} M2 V^{3+} has a high charge and small size OR V^{3+} has a high charge density M3 V^{3+} weakens the O–H bond (in water ligands and donates H^+ to water or forms H_3O^+ ions)	Allow as product $[V(H_2O)_6]_2(SO_4)_3$ M3 V^{3+} attracts electrons from the O-H bond (in ligand and releases H^+ or H_3O^+) OR V^{3+} polarises the O–H bond/water molecule	3 (1 x AO2, 2 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
07.7	M1 $Q + H^+ \rightarrow QH^+$ M2 602	Allow $C_{33}H_{34}N_4VO_4 + H^+ \rightarrow C_{33}H_{35}N_4VO_4^+$ Allow $C_{33}H_{34}N_4VO_4 + H^+ \rightarrow C_{33}H_{34}N_4VO_4H^+$ Ignore state symbols	2 (1 x AO1, 1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
07.8	M1 $\frac{51x + 49(100 - x)}{100} = 50.97$ M2 $^{51}V = x = 98.5\%$	Alternatives for M1 51x + 49(1-x) = 50.97, giving x = 0.985 Or $\frac{49x + 51(100 - x)}{100} = 50.97$, giving x = 1.5% for ^{49}V 98.5% scores M1 and M2	2 (2 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
08.1	M1 pH = $-\log_{10}[H^+]$ or pH = $-\log_{10}(0.150)$ M2 pH = 0.82	Correct value to 2dp scores 2 marks	2 (1 x AO1, 1 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
08.2	M1 $[H^+] = 10^{-pH} = 10^{-2.89}$ (= 1.29×10^{-3}) M2 Ka = $\frac{[H^+]^2}{[CH_3CH_2COOH]}$ OR = $\frac{[H^+]^2}{[HA]}$ M3 $[CH_3CH_2COOH] = \frac{[H^+]^2}{K_a} = \frac{(1.29 \times 10^{-3})^2}{1.35 \times 10^{-5}}$ M4 0.123 (mol dm^{-3})	M2 allow with numbers or symbols M3 allow rearrangement with numbers or symbols M4 0.12 to 0.13 to 2 significant figures or more scores 4 marks	4 (4 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
08.3	strong alkali added to weak acid		1 (1 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
08.4	these 3 indicators all ticked cresol red naphtholphthalein cresolphthalein		1 (1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
08.5	M1 OH^- ions react with H^+ M2 The $HA \rightleftharpoons H^+ + A^-$ equilibrium shifts right to maintain $[H^+]$ OR M2 ratio of $[CH_3COOH]$ / $[CH_3COO^-]$ remains roughly constant	Alternative M1 OH^- ions react with CH_3COOH/ethanoic acid/HA OR M1 $HA + OH^- \rightarrow H_2O + A^-$ M2 ratio of $[CH_3COOH]$ / $[CH_3COO^-]$ remains roughly constant	2 (2 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
08.6	M1 amount HA at start = $0.120 \times \frac{50}{1000} = 0.00600$ M2 amount A^- at start = $\frac{0.656}{82.0} = 0.00800$ M3 amount of H^+ added = $0.200 \times \frac{1.50}{1000} = 0.000300$ M4 amount of HA after reaction = M1 + M3 **and** amount of A^- after reaction = M2 – M3 M5 $[H^+] = K_a \frac{[\text{HA answer from M4}]}{[A^- \ answer \ from \ M4]} = 1.78 \times 10^{-5} \times \frac{\text{M1 + M3}}{\text{M2 – M3}}$ M6 pH = – log M5 M7 = 4.87 – M6	M1 amount HA at start = $0.120 \times \frac{50}{1000} = 0.00600$ M2 amount A^- at start = $\frac{0.656}{82.0} = 0.00800$ M3 amount of H^+ added = $0.200 \times \frac{1.50}{1000} = 0.000300$ M4 amount of HA after reaction = 0.0063 **and** amount of A^- after reaction = 0.0077 M5 is dependent on an attempt at M4 M5 $[H^+] = K_a \frac{[HA]}{[A^-]} = 1.78 \times 10^{-5} \times \frac{0.00630}{0.00770} = 1.46 \times 10^{-5}$ M6 pH = –log $1.46 \times 10^{-5} = 4.84$ M7 change = 4.87 – 4.84 = 0.03 (answer to 2 decimal places)	7 (7 x AO2)