A-level
CHEMISTRY
7405/1

Paper1 Inorganic andPhysical Chemistry

Mark scheme

June 2026

Version: 1.0 Final

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.

Nostudent 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.

Aconsistent 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 Inalist 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 exceededthemaximum number of responsessothereisno penalty.
1	2	0	They have exceededthemaximumnumber of responses sotheextraincorrect response cancelsthecorrectone.
2	0	2	
2	1	1	
2	2	0	
3	0	2	The maximummarkis2
3	1	1	The incorrect responsecancelsoutone of the two correct responsesthatgained credit.
3	2	0	Two incorrect responsescanceloutthe 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 consequentialinthe marking scheme.

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

3.4 Equations

In questionsrequiring students to write equations, state symbols are generally ignored unless otherwise stated in the 'Comments' column.

Examiners shouldalso credit correct equations using multiples and fractions unless otherwise statedinthe 'Comments' column.

3.5 Oxidation states

In general, the signfor an oxidation state will be assumed to be positive unless specifically showntobe 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 confusionwith another technical term or if the question requires correct IUPAC nomenclature.

3.8 Brackets

(…..) areused 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 $Ag(NH)^+_{32}$ 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.

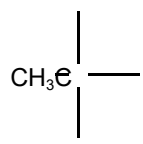
3.12 Organic structures

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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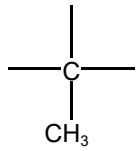

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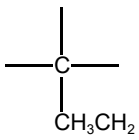

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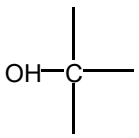

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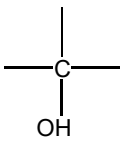

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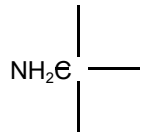

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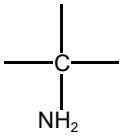

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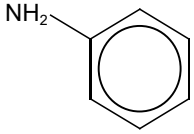

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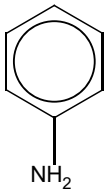

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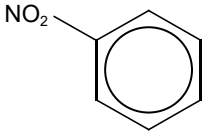

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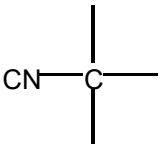

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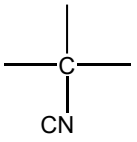

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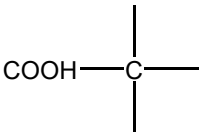

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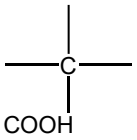

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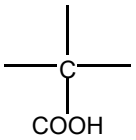

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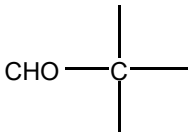

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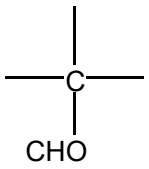

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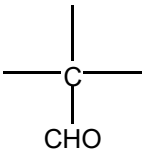

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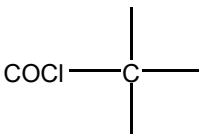

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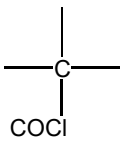

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- Representation of CH_2 by $C{-}H_2$willbe penalised
- Some examples are given hereof**structures** forspecific compounds that should **not** gain credit (but, exceptions **may**bemade in thecontext of balancing equations)

CH_3COH	for	ethanal
CH_3CH_2HO	for	ethanol
$OHCH_2CH_3$	for	ethanol
$C2H_6O$	for	ethanol
CH_2CH_2	for	ethene
$CH_2.CH_2$	for	ethene
$CH_2{:}CH_2$	for	ethene

- Each of the following **shouldgain 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.

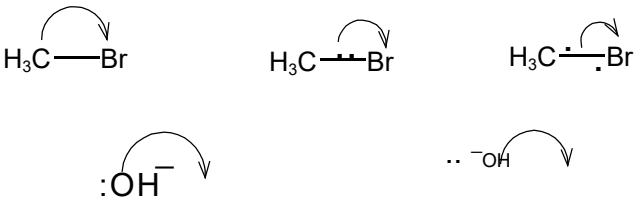
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

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**

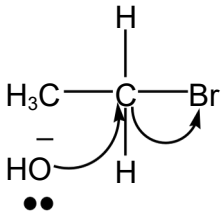
3.14 Organic reaction mechanisms

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 formationof 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, eachofwhich has a descriptor. Each descriptor contains two statements. The first statementisthe Chemistry content statement and the second statement is the communication statement.

Determining a level
Start at the lowestlevelof the mark scheme and use it as a ladder to see whether the answer meets the Chemistrycontent descriptor for that level. The descriptor for the level indicates the qualities that mightbeseen in the student's answer for that level. If it meets the lowest level, then go to the next oneanddecide if it meets this level, and so on, until you have a match between the level descriptor andtheanswer.

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 linkagewords (such as 'therefore', 'so', 'because' etc), these are optional. However, a student's marksforthe question may be limited if they do not demonstrate the ability to construct and developasustained line of reasoning which is coherent, relevant, substantiated and logically structured.Inparticular answers in the form of bullet pointed lists may not be awarded full marks if thereisnoindication of logical flow between each point or if points are in an illogical order.

The mark schemes for some questionsstate that the maximum mark available for an extended response answer is limited if the answerisnot coherent, relevant, substantiated and logically structured. During the standardisationprocess, the Lead Examiner will provide marked exemplar material to demonstrate answers whichhave not met these criteria. You should use these exemplars as a comparison when markingstudent answers.

Question	Answers	Additional comments/Guidelines	Mark
01.1	p (block)	Do not accept 3p	1

Question	Answers	Additional comments/Guidelines	Mark
01.2	$Al(g) \rightarrow Al^+(g) + e^-$	$Al(g) - e^- \rightarrow Al^+(g)$ $Al(g) + e^- \rightarrow Al^+(g) + 2e^-$ State symbols essential	1

Question	Answers	Additional comments/Guidelines	Mark
01.3	**Z**		1

Question	Answers	Additional comments/Guidelines	Mark
01.4	(2^{nd}) electron is removed from a lower energy (3s) subshell/orbital (in Al^+) Or (Al^+ has a smaller radius so) electron lost is closer to the nucleus (and therefore needs more energy to remove) Or Harder to remove an electron from a positively charged species/ion	Do not accept references to Al^{2+} or Al^{3+} Ignore references to shielding Answers need to be comparative Do not accept difference in nuclear charge Do not accept shell/level instead of subshell/orbital	1

Question	Answers	Additional comments/Guidelines	Mark
01.5	M1 Si is giant covalent (lattice) or macromolecular M2 Al is metallic (lattice) M3 Covalent bonds in Si are stronger than metallic bonds in Al Or More energy needed to break covalent bonds in Si than metallic bonds in Al Or Harder to break covalent bonds in Si than metallic bonds in Al	Mark independently M3 is a comparison between the bonding in Si and the bonding in Al Covalent bonds stronger than metallic bonds is insufficient Allow attraction between positive ions/nuclei and delocalised electrons for metallic bonding. Do not allow references to IMFs in M3 Do not allow references to attraction between ions/ionic bonding in M3	3

Question	Answers	Additional comments/Guidelines	Mark
02.1	M1 Enthalpy change when 1 mol of ionic solid or 1 mol of ionic lattice M2 is formed from its gaseous ions.	Allow Heat energy change (at constantpressure) when 1 mol of ionic solid or 1 mol of ioniclattice Ignore references to standard conditions Do not accept enthalpy needed/required Allow 2 marks for: enthalpy change for: $M^+(g) + X^-(g) \rightarrow MX(s)$ or $Sr^{2+}(g) + 2Br^-(g) \rightarrow SrBr_2(s)$	2

Question	Answers	Additional comments/Guidelines	Mark
02.2	$Sr^+(g) + e^- + 2\,Br(g)$ $Sr(g) + 2\,Br(g)$ OR $Sr^{2+}(g) + 2\,e^- + Br_2(l)$ $Sr^+(g) + e^- + Br_2(l)$		2

Question	Answers	Additional comments/Guidelines	Mark
02.3	M1 2 × EA Br = –716 – 164 – 548 – 1060 – (**2** × 112) + 2075 M2 = –637 (kJ mol^{-1}) M3 = M2 ÷ 2	If 1 × 112 used in M1, award M2 for –525, and allow consequential M3 = –262.5 ie max 2 marks M2 must be exothermic M3 = EA Br = –319 / –318.5 (kJ mol^{-1})	3

Question	Answers	Additional comments/Guidelines	Mark
02.4	M1 –72 = (+)2075 – 1480 + 2y M2 2y = –667 M3 enthalpy change = ~~*MM*~~2 with – sign 2	M1 Allow a correct Hess's Law cycle. M3 enthalpy change = –333.5 or –334 (kJ mol^{-1}) IfM1 uses +72, M2 = –523 and M3 = –261.5 IfM1 uses +1480, M2 = –3627 and M3 = -1813.5 Can access M2 and M3 IfM1 uses –2075, M2 = 3483 (and M3 = 1741.5) Can access M2 only as M3 must be negative Max 2 marks if not divided by 2 Allow answers to 2 significant figures or more	3

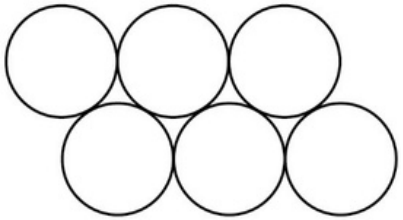
Question	Answers	Additional comments/Guidelines	Mark
03.1	$Ba(s) + 2H_2O(l) \rightarrow Ba(OH)_2(aq) + H_2(g)$ OR $Ba(s) + 2H_2O(l) \rightarrow Ba^{2+}(aq) + 2OH^-(aq) + H_2(g)$	state symbols essential allow multiples	1

Question	Answers	Additional comments/Guidelines	Mark
03.2	increase down group	Allow more soluble down the group	1

Question	Answers	Additional comments/Guidelines	Mark
03.3	Indigestion relief/tablet/remedy OR Laxative OR To neutralise stomach acid/antacid	Allow Milk of Magnesia	1

Question	Answers	Additional comments/Guidelines	Mark
03.4	white precipitate/solid $Ba^{2+}(aq) + SO^{2-}_4(aq) \rightarrow BaSO_4(s)$ state symbols needed	State symbols essential	2

Question	Answers	Additional comments/Guidelines	Mark
03.5	reducing agent/electron donor $TiCl_4 + 2\ Mg \rightarrow 2\ MgCl_2 + Ti$	Do not accept electron pair donor Allow multiples Ignore state symbols	2

Question	Answers	Additional comments/Guidelines	Mark
03.6	M1 Regular arrangement of particles  M2 <u>delocalised</u> electrons move/flow M3 <u>attraction</u> between (positive) metal ions and <u>delocalised</u> electrons Or <u>attraction</u> between nuclei of metal atoms and <u>delocalised</u> electrons M4 strong attraction (that need to be overcome)	Mark M1 independently Minimum of 6 metal (ion) particles in at least 2 rows in a regular pattern Allow circles to be empty, or with (1)+ or with 2+ Delocalised electrons not essential in diagram Allow M4 for strong (metallic) bonds between metal ions and <u>delocalised</u> electrons Or strong (metallic) bonds between nuclei of metal atoms and <u>delocalised</u> electrons Ignore references to heat energy in M4	4

Question	Answers	Additional comments/Guidelines	Mark
04.1	100 kPa **and** a stated temperature/298 K	Allow standard pressure or 1 bar Allow temperature in °C Do not accept 1 atm or 101 kPa Do not accept concentration or standard states	1

Question	Answers	Additional comments/Guidelines	Mark
04.2	M1 two straight lines of best fit M2 5.2 (°C)	For M1 lines must extend to or past 4 minutes For M2, allowed range = 5.1 to 5.4 (°C)	2

Question	Answers	Additional comments/Guidelines	Mark
04.3	M1 Q = 50 × 4.18 × answer to Q4.2 M2 amount of Na_2CO_3 = $\frac{5.05}{106}$ = 0.0476 mol M3 = $\frac{M}{M1}$ M4 = $\frac{\frac{M}{M2}}{\frac{MM3}{1000}}$ and must be negative	M1 Q = 50 × 4.18 × 5.2 = 1087 J Allow M1 = 209 × ΔT M3 ΔH = $\frac{(-)1087}{0.0476}$ = (–)22832 J mol^{-1} M4 –22.8 kJ mol^{-1} must have – sign Minimum of 2 significant figures	4

Question	Answers	Additional comments/Guidelines	Mark
04.4	(Due to) heat loss Or Thermometer uncertainty is greater than that for the balance OR the volume/temperature only given to 1 decimal place OR Data are to 3 significant figures (and 3 decimal places is 4 significant figures)		1

Question	Answers	Additional comments/Guidelines	Mark
04.5	(to take account for) heat loss OR to account for a cooling correction OR reaction not instantaneous OR (to give a) more accurate temperature change	Ignore time for thermometer to register temperature	1

Question	Answers	Additional comments/Guidelines	Mark
05.1	$[Fe(H_2O)_4(OH)_2]$	$[Fe(OH)_2(H_2O)_4]$ Allow without square brackets Do not accept OH^- Do not accept $Fe(OH)_2$	1

Question	Answers	Additional comments/Guidelines	Mark
05.2	Na_2CO_3	Do not allow CO^{2-}_3 Any Group 1 carbonate or ammonium carbonate	1

Question	Answers	Additional comments/Guidelines	Mark
05.3	brown precipitate $[Ag(NH_3)_2]^+$	Allow orange-brown precipitate or light/dark brown precipitate Allow $[Ag(NH_3)_2]Cl$ and $[Ag(NH_3)_2]OH$	2

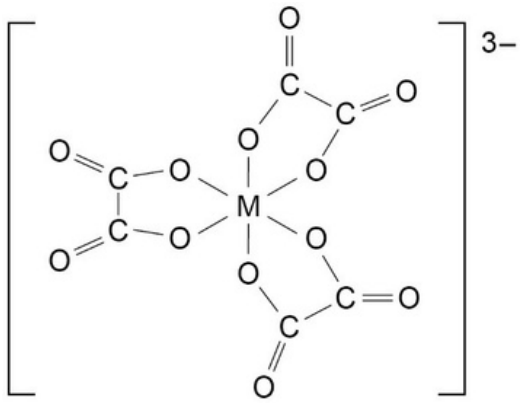
Question	Answers	Additional comments/Guidelines	Mark
05.4	M1 $[Fe(H_2O)]_6^{3+} + H_2O \rightleftharpoons [Fe(H_2O)_5(OH)]^{2+} + H_3O^+$ OR $[Fe(H_2O)_6]^{3+} \rightleftharpoons [Fe(H_2O)_5(OH)]^{2+} + H^+$ M2 Fe^{3+} has a high charge density OR high charge **and** small size M3 polarises/weakens/breaks the O–H bond (in water ligand) M4 releasing H^+ ions	Allow equations to form $[Fe(H_2O)_4(OH)_2]^+$ $Fe(H_2O)_6^{3+} \rightleftharpoons [Fe(H_2O)_4(OH)_2]^+ + 2H^+$ $[Fe(H_2O)_6]^{3+} + 2H_2O \rightleftharpoons [Fe(H_2O)_4(OH)_2]^+ + 2HO^+_3$ M2: Do not allow $[Fe(H_2O)_6]^{3+}$ has a high charge density	4

Question	Answers	Additional comments/Guidelines	Mark
06.1	Oxidation half-equation $C_2O_4^{2-} \rightarrow 2CO + 2e^-$ Reduction half-equation $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ If both equations correct but in wrong order allow 1 mark	Allow multiples	2

Question	Answers	Additional comments/Guidelines	Mark
06.2	It would be oxidised by $KMnO_4/MnO_4^-$ (to chlorine) Or HCl/Cl^- reduces/reacts with $KMnO_4/MnO_4^-$ Or would cause titre to be higher	Allow would oxidise to chlorine or forms chlorine	1

Question	Answers	Additional comments/Guidelines	Mark
06.3	M1 Amount of MnO_4^- = 24.85 × 10^{-3} × 0.02 = 4.97 ×10^{-4} mol M2 Amount of $C_2O_4^{2-}$ = M1 × $\frac{5}{2}$ M3 Amount of CO_{24}^{2-} in250 cm^3 = M2 × 10 M2 and M3 either order M4 n $K_3[\mathbf{M}(C_2O_4)_3]$ = $\frac{M3}{3}$ M5 M_r $K_3[\mathbf{M}(C_2O_4)_3]$ = $\frac{181}{M4}$ M6 A_r **M** $K_3[\mathbf{M}(C_2O_4)_3]$ = M5 – 381(.3) M7 identification of metal which forms 3+ ion	M1 Amount of MnO_4^- = 24.85 × 10^{-3} × 0.02 = 4.97 × 10^{-4} mol M2 Amount of CO_{24}^{2-} = $\frac{5}{2}$×4.97× 10^{-4} = 1.24 × 10^{-3} mol M3 Amount of $C_2O_4^{2-}$ in 250 cm^3 = 1.24 × 10^{-2} mol M4 n $K_3[\mathbf{M}(C_2O_4)_3]$ = $\frac{1.24}{3}$ × 10^{-2} = 4.14 × 10^{-3} mol M5 M_r $K_3[\mathbf{M}(C_2O_4)_3]$ = $\frac{1.81}{4.14\times10^{-3}}$ = 437 M6 A_r **M** $K_3[\mathbf{M}(C_2O_4)_3]$ =437 –(3 × 39.1) – (3 × 88) =55.7 or 56 M6 could be negative as long as M5 – 381.3 (process mark) M7 Fe Allow Fe^{3+} To gain M7, must have M6 = M5 – 381(.3) If 5 omitted, M6 = 712 so can access M1, M3, M4, M5 and 2M6 If 2 used, M6 = 2350 so can access M1, M3, M4, M5 and M6 If 5 omitted, M5 = 146 so can access M1, M2, M3, M5 and 3M6 If × 10 is omitted, M6 = 3989 so can access M1, M2, M4, M5 and M6	7

Question	Answers	Additional comments/Guidelines	Mark
06.4	M1initially the reaction/rate is slow M2two (negative) ions repel Or the reaction has a high activation energy M3then reaction speeds up/rate increases M4Mn^{2+} is the (auto)catalyst M5reaction gets slower as concentration of reactants/ MnO^-_4 decreases	M4 Allow Mn^{3+} (auto)catalyst Allow Mn^{2+}/Mn^{3+} lowers activation energy M5 Rate decreases as reactants/MnO^-_4 used up Ignore equations	5

Question	Answers	Additional comments/Guidelines	Mark
06.5	 Optical	Charge must be included Allow skeletal structure Ignore brackets	2

Question	Answers	Additional comments/Guidelines	Mark
07.1	M1 = $[H^+] = \sqrt{(1.47 \times 10^{-14})} = 1.21 \times 10^{-7}$ M2 = pH = –logM1 M3 = $[H^+] = [OH^-]$	M2 pH = 6.92 Allow pH = 6.9 Do not accept pH 6.91 and pH 7.0 M3 Amount/moles H+ = amount/moles OH^-	3

Question	Answers	Additional comments/Guidelines	Mark
07.2	M1 $[H^+] = 10^{-pH}$ M2 $[OH^-] = \frac{-14}{1.47\ xx\ 10^{MM1}}$	M1 $[H^+] = 1.00 \times 10^{-7}$ mol dm^{-3} M2 $[OH^-] = 1.47 \times 10^{-7}$ mol dm^{-3}	2

Question	Answers	Additional comments/Guidelines	Mark
07.3	M1 amount of HCOOH at start = $8.00 \times 10^{-3} \times 2.00 = 0.0160$ mol M2 amount of NaOH = $5.00 \times 10^{-3} \times 1.50 = 0.0075$ mol = amount A^- M3 amount of HCOOH after adding NaOH = M1 – M2 M4 $K_a = \frac{[H^+][AA^-]}{[HHAA]}$ or $[H^+] = K_a \frac{[HHAA]}{[AA^-]}$ M5 ($K_a = \frac{[H^+]MM2}{MM3}$ or $[H^+] = K \frac{MM3}{MM2}$) evaluation of $[H^+] = K \frac{M3}{M2}$ M6 = pH = –log M5 answer to 2 decimal places Alternative Henderson-Hasselbalch Equation M1 pH = p K_a + log[salt]/[acid] M5 pH = 3.75 + log 0.8824 pH = 3.75 – 0.054	M3 amount of HCOOH after adding NaOH = 0.0085 mol M4 expression M5 $[H^+] = 1.78\times10^{-4} \times \frac{8.5 \times 10^{-3}/V}{7.5 \times 10^{-3}/V}$ Or $= 1.78\times10^{-4} \times \frac{0.654}{0.577}$ $= 2.02\times10^{-4}$ mol dm^{-3} Only award M5 if M3 is attempted. M6 pH = 3.69 or 3.70 and answer to 2 decimal places Incorrect rearrangement of Ka expression loses M5	6

	M6 pH = 3.70 answer to 2 decimal places	IfM3 is omitted, pH = 3.42 so can access M1, M2, M4 and M6	

Question	Answers	Additional comments/Guidelines	Mark
07.4	**M1** H^+ (from HCl) reacts with A^-/$HCOO^-$ /salt (ions) **M2** The HA $\rightleftharpoons$ $H^+ + A^-$ equilibrium shifts left to oppose the change/oppose the increase in $[H^+]$ OR **M2** ratio of $[HCOOH]:[HCOO^-]$ or [acid]:[salt] remains (roughly) constant	Ignore acid reacts with A^-/$HCOO^-$ Ifequilibrium referenced in M2 then that equation must be shown	2

Question	Answers	Additional comments/Guidelines	Mark
07.5	to avoid diluting (the solution)	Allow water affects the concentration (of the solution) Do not accept contamination Ignore changes in pH Ignore references to recalibrating the pH probe	1

Question	Answers	Additional comments/Guidelines	Mark
07.6	Answer key: C - thymol blue		1

Question	Answers	Additional comments/Guidelines	Mark
07.7	Volume of NaOH = 19.6 cm^3 (allow 19.4 to 19.6) M1 Amount of NaOH = $\frac{\text{Volume} \times 0.100}{1000}$ M2 Concentration of acid = $\frac{1000}{\text{M1} \times 25}$ **alternative method** pH at the start = 2.43 M1 = $[H^+] = 10^{-pH}$ M2 = $\frac{1.78 \, xx \, 10^{-4}}{MM1^2}$	M1 Amount of NaOH = $\frac{19.6 \times 0.100}{1000} = 1.96 \times 10^{-3}$ mol M2 Concentration of acid = $\frac{1.96 \times 10^{-3} \times 1000}{25}$ =0.078 mol dm^{-3} Answers to a minimum of 2 significant figures **alternative method** Allow pH = 2.4 to 2.5 and consequential answer from that M1 $[H^+] = 10^{-2.43}$ OR 3.72×10^{-3} mol M2 $((10^{-2.43})^2 \div 1.78 \times 10^{-4}) = 0.078$ mol dm^{-3} If initial pH = 2.4, [HA] = 0.089 mol dm^{-3} If initial pH = 2.5, [HA] = 0.056 mol dm^{-3} Answers to a minimum of 2 significant figures	2 (2 × AO2)

Question	Answers	Additional comments/Guidelines	Mark
07.8	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 stagesare covered but the description of each stage may be incompleteormay contain inaccuracies, OR only one stage is covered butthe 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.	See indicative chemistry content on next page	6 (6 × AO3)

	Stage 1: Hydrochloric acid and nitric acid	Stage 2: Sulfuric acid	Stage 3: Ethanoic acid
(a)	**Description of Acids** Both strongacids Or Both fully ionised/dissociated Or $HCl \rightarrow H^+ + Cl^-$ **and** $HNO_3 \rightarrow H^+ + NO_3^-$	**Description of Acid** Diproticacid (whereasothers are monoprotic) Or Has/releases 2 $H^{(+)}$ (per mole of acid) Or $H_2SO_4 \rightarrow 2\ H^+ + SO_4^{2-}$	**Description of Acid** Ethanoic acid is aweakacid Or ethanoic acid is only slightly/partially ionised/dissociated Or $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$ must have equilibrium sign
(b)	**Equations** $HCl + NaOH \rightarrow NaCl + H_2O$ and $HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$ Or $H+ + OH^- \rightarrow H_2O$	**Equations** $H_2SO_4 + 2\ NaOH \rightarrow Na_2SO_4 + 2\ H_2O$ Or $2H^+ + 2OH^- \rightarrow 2H_2O$	**Equations** $CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$
(c)	**Data analysis** All theneutralisations/reactions are exothermic Or All the values are negative because they all involve bond formation	**Data analysis** Value is $2 \times -57 = -114$ Or Value is 2 x HCl or HNO_3 value	**Data analysis** Dissociation/ionisation of the weak acid is endothermic Or (Enthalpy change/ΔH is) less/least exothermic (than strong acids) Or Some of the energy is used to dissociate/ionise /break bonds in the acid

Question	Answers	Additional comments/Guidelines	Mark
08.1	more moles/molecules/particles (of gas) on right hand side or products have more disorder	Allow 4 moles (of gas) on left and 5 moles (of gas) on right Allow more moles of products Ignore entropy increases	1

Question	Answers	Additional comments/Guidelines	Mark
08.2	M1 ΔH = (4 × –92) – (2 × –242) M2 = 116 (kJ mol^{-1}) M3 $T = \frac{\Delta H}{\Delta S}$ M4 ΔS = 129 × 10^{-3} (kJ K^{-1} mol^{-1}) M5 T = M2 must be a positive value M4	M2 allow 1 mark for –116 (kJ mol^{-1}) and lose M1 M4 Or allow ΔH = 116 x 10^{3} (J mol^{-1}) M5 $T = \frac{116}{129 \times 10^{-3}}$ = 899(.2)to900(K) Or $T = \frac{116 \times 10^{3}}{129}$ =899(.2) to 900(K) = IfM5 = 1163 K can access M3 and M4 and M5 Ifincorrect rearrangement in M3 can access M1, M2 and M4	5

Question	Answers	Additional comments/Guidelines	Mark
08.3	**M1** Yield would increase/more SO_3 produced **M2** The reaction is exothermic **M3** The <u>equilibrium</u> shifts/moves (to the right) to oppose the temperature decrease/to oppose the change (in temperature)/to increase the temperature	Mark each point independently Ignore reference to forward reaction being favoured. M2 Allow reverse reaction is endothermic In M3 equilibrium must move or shift	3

Question	Answers	Additional comments/Guidelines	Mark
08.4	M1 T = 673 K and V = 0.025 m^3 M2 n $\frac{PV}{RT}$ OR n $\frac{100\,000\times0.025}{8.31\times673}$ = = M3 n gas = 0.447 mol M4 n $LiNO_3$ = M3 × $\frac{4}{5}$ M5 = M4 × 68.9 answer must be to 3 significant figures	M2 uses values from M1 IfM2 is an incorrect rearrangement, can access M1, M4 and M5 M4 n $LiNO_3$ = 0.447 × $\frac{4}{5}$ = 0.358 mol M5 mass $LiNO_3$ = 0.358 × 68.9 = 24.7 g Allow 24.6 or 24.7 g	5

Question	Answers	Additional comments/Guidelines	Mark
08.5	M1 sodium / Na M2 $Na_2O + H_2O \rightarrow 2\,NaOH$	In M2 Ignore state symbols Allow multiples Allow ecf in M2 for Mg only in M1	2

Question	Answers	Additional comments/Guidelines	Mark
08.6	M1 Aluminium M2 $Al_2O_3 + 6\,HCl \rightarrow 2\,AlCl_3 + 3\,H_2O$ OR $Al_2O_3 + 6\,H^+ \rightarrow 2\,Al^{3+} + 3\,H_2O$ M3 $Al_2O_3 + 2\,NaOH + 3\,H_2O \rightarrow 2\,Na[Al(OH)_4]$ OR $Al_2O_3 + 2\,OH^- + 3\,H_2O \rightarrow 2[Al(OH)_4]^-$ OR $Al_2O_3 + 2\,OH^- + 7H_2O \rightarrow 2[Al(OH)_4(H_2O)_2]^-$	Do not accept forming Al_2Cl_6 Do not accept equations from $[Al(H_2O)_6]^{3+}$ For M2 allow $Al_2O_3 + 6\,HCl + 9\,H_2O \rightarrow 2\,[Al(H_2O)_6]^{3+} + 6Cl^-$ OR $Al_2O_3 + 6\,H^+ + 9\,H_2O \rightarrow 2\,[Al(H_2O)_6]^{3+}$ For M3 allow $Al_2O_3 + 6OH^- + 3H_2O \rightarrow 2\,[Al(OH)_6]^{3-}$ $Al_2O_3 + 6\,NaOH + 3\,H_2O \rightarrow 2\,Na_3[Al(OH)_6]$ Allow equations to form $[Al(OH)_3(H_2O)_3]^{2-}$ For 2 correct equations the wrong way round, allow 1 mark for both equations	3

Question	Answers	Additional comments/Guidelines	Mark
08.7	amphoterism / shows amphoteric character / amphoteric		1