A-level

CHEMISTRY

7405/3

Paper 3

Mark scheme

June 2025

Version: 1.0 Final

256A7405/3/MS

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

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

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

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

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

AS and A-Level Chemistry
Mark Scheme Instructions for Examiners

1. General

The mark scheme for each question shows:

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

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

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

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

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

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

2. Emboldening

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

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

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

3. Marking points

3.1 Marking of lists

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

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

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

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

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

3.2 Marking procedure for calculations

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

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

3.3 Errors carried forward, consequential marking and arithmetic errors

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

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

3.4 Equations

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

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

3.5 Oxidation states

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

3.6 Interpretation of 'it'

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

3.7 Phonetic spelling

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

3.8 Brackets

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

3.9 Ignore / Insufficient / Do <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.

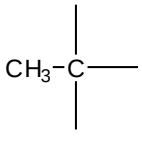
3.12 Organic structures

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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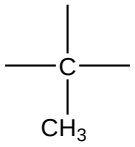

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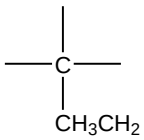

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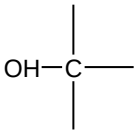

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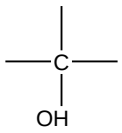

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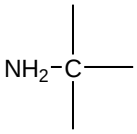

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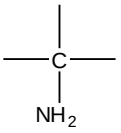

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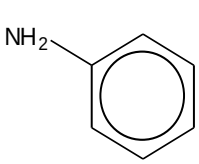

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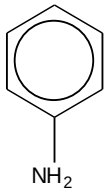

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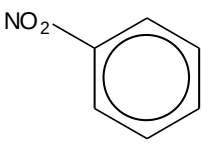

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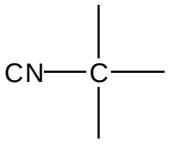

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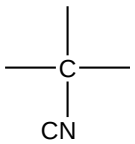

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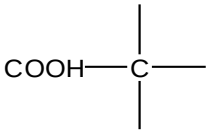

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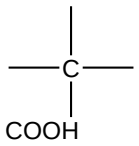

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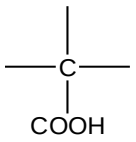

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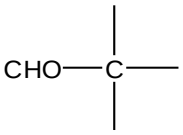

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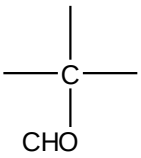

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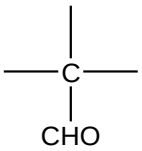

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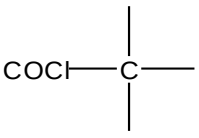

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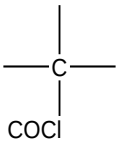


not allowed

- 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.

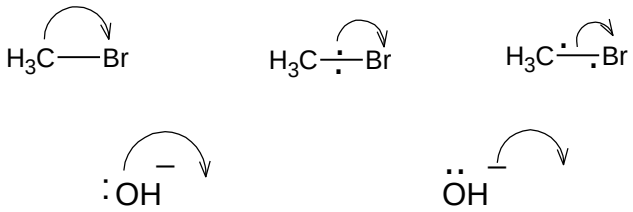
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

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**

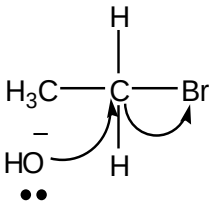
3.14 Organic reaction mechanisms

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	$KOH(s) \rightarrow K^+(aq) + OH^-(aq)$ **OR** $KOH(s) + aq \rightarrow K^+(aq) + OH^-(aq)$ State symbols are essential	**ALLOW** (+)aq on arrow **ALLOW** KOH(aq) as product **IGNORE** H_2O on arrow **NOT** equations with H_2O on the LHS and/or RHS **NOT** ⇌	1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
01.2	M1 Amount of KOH = $\frac{3.00}{56.1}$ (= 0.053475935 mol) M2 q = Δ*H* x M1 M3 ΔT = 30.4 – 18.1 (= 12.3 °C) M4 m (= $\frac{q}{c\Delta T}$) = $\frac{\text{M2 in J}}{4.18 \times \text{M3}}$ M5 = answer to M4 in cm^3	M2 q = ΔH × 0.0535 (= 2.74455 kJ) = 2745 J For M2, M1 must be an attempt at calculating amount of KOH M4/M5 **ALLOW** actual answers OR actual answers minus 3 if mass KOH subtracted = 49.8 – 50.4 g M4 **ALLOW** m (= $\frac{q}{c\Delta T}$) = $\frac{\text{M2 in kJ}}{4180 \times \text{M3}}$ M4 **ALLOW** if M2 left in kJ if M5 in dm^3 52.8 – 53.4 cm^3 = 5 marks Answer must be to min 2 sig. fig. **and** units of cm^3 **ALLOW** units of dm^3 only if answer given as 0.0528 - 0.0534 dm^3 to min 2 sf M5 2.30 cm^3 from ΔT = 12.3 + 273 (NOT M3) M5 0.998 cm^3 comes from 51.3 / 4.18 x 12.3 = M3 & M5 (NOT M2 & M4). Look for M1 separately M5 998 cm^3 comes from 51300 / 4.18 x 12.3 = M3, M4 & M5 (NOT M2). Look for M1 separately	5 (4 x AO2, 1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
01.3	M1 Enthalpy of solution = enthalpy of hydration K^+ + enthalpy of hydration OH^- – Lattice enthalpy of formation **OR** = –322 – 528 – (–789) **OR** –789 + x = –322 + (–528) M2 –61 (kJ mol^{-1})	OR cycle $KOH(s) \rightarrow K^+(aq) + OH^-(aq)$ –789 –322 –528 $K^+(g) + OH^-(g)$ –61 = 2 marks +61 = 1 mark –1639 = 1 mark **NOT** +1639 (0 marks)	2 (2 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
01.4	Heat losses **OR** incomplete dissolving	**ALLOW** incomplete dissociation/reaction **ALLOW** solution made in experiment is not to infinite dilution **ALLOW** thermal energy for 'heat' **IGNORE** not standard conditions / covalent character / evaporation of water / apparatus uncertainty **IGNORE** energy loss unqualified **IGNORE** human error **IGNORE** incomplete hydration **NOT** data book values are averages **NOT** incomplete combustion **NOT** heat gain **NOT** references to yield	1 (1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
02.1	Any 3 • temperature • amount/volume of starch • total volume / volume of reaction mixture • (constant) stirring/agitation • same person observing colour change / same shade of colour when timing stopped	**ALLOW** concentration/mass of starch **IGNORE** same stopwatch **IGNORE** concs/vols/amounts of thiosulfate & other reagents **IGNORE** references to (same) apparatus **IGNORE** same person unqualified	3 (3 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
02.2	M1 1st / one for H_2O_2 **AND** 1st / one for I^- **AND** zero / 0 for H^+ M2 Doubling $[I^-]$ halves the time M3 (Use experiments 3 and 4) because $[H^+]$ and $[H_2O_2]$ stay the same **OR** because only $[I^-]$ changes	M2 is independent of M1 M2 **ALLOW** doubling $[I^-]$ doubles the rate **ALLOW** M2 **AND** M3 for when $[I^-]$ doubles and $[H^+]$ and $[H_2O_2]$ stay the same the time halves / rate doubles **ALLOW** any correct explanation based on two experiments and orders wrt H_2O_2 and/or H^+	3 (3 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
02.3	M1 rate = k $[H_2O_2]$ $[I^-]$ M2 mol^{-1} dm^3 s^{-1}	M1 ALLOW rate = k $[H_2O_2]^1$ $[I^-]^1$ $[H^+]^0$ **ALLOW** M1 independent of 02.2 if correct but ECF from 02.2 for other answers **NOT** () M2 dependent on a rate equation in M1 M2 **ALLOW** any order of mol dm s M2 **ALLOW** if no answer to M1	2 (2 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
02.4	M1 (amount of $S_2O_3^{2-}$ = $\frac{1.00 \times 10^{-3}}{\frac{1.00}{1000}}$ = 1.00×10^{-6} mol) amount of I_2 = ½ × amount of $S_2O_3^{2-}$ = $\underline{5.00 \times 10^{-7}\ mol}$ M2 $[I_2] = \frac{M1}{\frac{40}{1000}}$ M3 rate = $\frac{M2}{20}$	= 1.25×10^{-5} mol dm^{-3} For M2, M1 must be an attempt at calculating amount of I_2 = 6.25×10^{-7} (mol dm^{-3} s^{-1}) (= 3 marks) (at least 2sf so ALLOW 6.3×10^{-7}) M3 if no M2 **ALLOW** mol of iodine from M1/20 e.g. $5 \times 10^{-7} / 20 = 2.5 \times 10^{-8}$ (= 2 marks, M1 & M3)	3 (3 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
02.5	(observer) reaction time / time taken to stop timer (is more significant) / hard to determine 'end point' / colour change not instantaneous	**IGNORE** 'human error' unqualified	1 (1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
02.6	2.5 (%)	**NOT** 2.55	1 (1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
02.7	M1 increase the time (and so reduces percentage uncertainty) M2 use a greater concentration/amount of thiosulfate	**ALLOW** greater volume of thiosulfate **ALLOW** lower temperature **IGNORE** use of colorimeter **IGNORE** references to starch **IGNORE** references to repeats / averages **NOT** lower/greater total volume / adding water / lower/greater concentrations of reactants	2 (2 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
03.1	M1 mistake: the concentration of H_2SO_4 **OR** $[H^+] \neq 1$ mol dm^{-3} change: use 0.5 mol dm^{-3} H_2SO_4 **OR** 1 mol dm^{-3} HCl / HNO_3 M2 mistake: NaOH / wrong substance on filter paper/salt bridge change: use KNO_3 M3 mistake: Fe / wrong electrode/metal (on RHS) change: Pt	**ALLOW** 1 mark for 3 mistakes if no other mark It must be clear that it is the concentration that is wrong, not the identity of the acid **ALLOW** 1 mol dm^{-3} H^+ for the change **ALLOW** if NaOH not mentioned e.g. salt bridge would react with H_2SO_4 **ALLOW** suitable alternative (name or formula) e.g. KCl **ALLOW** graphite **OR** different named unreactive metal e.g. Au, Ag (**NOT** Cu)	3 (3 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
03.2	High resistance		1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
03.3	$2\ Fe^{3+} + H_2 \rightarrow 2\ Fe^{2+} + 2\ H^+$	**ALLOW** multiples/fractions **IGNORE** state symbols **NOT** ⇌	1 (1 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
03.4	M1 Cu is the brown (solid) M2 Fe^{2+} is the (pale) green (solution) M3 because $E^{\ominus}$ Fe^{2+}/Fe more negative than $E^{\ominus}$ Cu^{2+}/Cu **OR** because $E^{\ominus}$ Cu^{2+}/Cu more positive than $E^{\ominus}$ Fe^{2+}/Fe M4 $Cu^{2+} + Fe \longrightarrow Cu + Fe^{2+}$ M5 Fe(s) | Fe^{2+}(aq) || Cu^{2+}(aq) | Cu(s) (State symbols required) M6 (+)0.78 (V)	**IGNORE** Fe^{3+} is brown **ALLOW** reference to +ve EMF of the correct cell/reaction **ALLOW** $E^{\ominus}$ Fe^{2+}/Fe < $E^{\ominus}$ Cu^{2+}/Cu OR $E^{\ominus}$ Cu^{2+}/Cu > $E^{\ominus}$ Fe^{2+}/Fe References to the half-cells / half-equations must refer to both Fe and Fe^{2+} (in either order) AND to Cu and Cu^{2+} (in either order) to identify the half-equations. **IGNORE** $E^{\ominus}$ Fe^{2+}/Fe greater than or less than $E^{\ominus}$ Cu^{2+}/Cu **IGNORE** state symbols **NOT** ⇌ M5 ECF from M4 where clear which two half equations are being used; but LHS and RHS of cell representation must match direction of reaction in M4 for incorrect half equations **ALLOW** Cu(s) | Cu^{2+}(aq) || Fe^{2+}(aq) | Fe(s) only if $Fe^{2+} + Cu \longrightarrow Fe + Cu^{2+}$ in M4 M6 ECF from M4 or M5 where clear which two half equations are being used **NOT** negative EMF	6 (2 x AO2, 4 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
04.1	(K_c =) $\frac{[Fe^{2+}]^2\,[I_2]}{[Fe^{3+}]^2\,[I^-]^2}$	**IGNORE** state symbols **NOT** ()	1 (1 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
04.2	M1 (dilution and cooling) stops the reaction **OR** reduces rate M2 during the titration no more iodide formed **OR** during the titration the equilibrium will not shift	M1 **ALLOW** concentrations/amounts stay constant M2 **NOT** iodide concentration remains constant during titration	2 (2 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
04.3	M1 initial amount of $Fe^{3+} = \frac{50 \times 0.015 \times 2}{1000} = 1.5 \times 10^{-3}$ mol **AND** initial amount of $I^- = \frac{50 \times 0.015}{1000} = 7.5 \times 10^{-4}$ mol M2 amount of I^- reacted = M1 I^- – 3 x 10^{-4} M3 for equilibrium amounts in mol Fe^{3+} = (M1 Fe^{3+} – M2) **AND** Fe^{2+} = M2 **AND** $I_2 = (\frac{M2}{2})$ M4 equilibrium concentrations in mol dm^{-3} $[I^-]$ = 3 x 10^{-3} **AND** $[Fe^{3+}] = \frac{M3\ Fe^{3+}}{0.1}$ **AND** $[Fe^{2+}] = \frac{M3\ Fe^{2+}}{0.1}$ **AND** $[I_2] = \frac{M3\ I_2}{0.1}$ M5 $K_c = \frac{(M4\ Fe^{2+})^2 \times M4\ I_2}{(M4\ Fe^{3+})^2 \times (M4\ I^-)^2}$ M6 units = $mol^{-1}\ dm^3$	M2 = 4.5 × 10^{-4} mol M3 Fe^{3+} = 1.05 × 10^{-3} / 0.00105 mol Fe^{2+} = 4.5 × 10^{-4} / 0.00045 mol I_2 = 2.25 × 10^{-4} / 0.000225 mol M4 $[I^-]$ = 3 × 10^{-3} / 0.003 mol dm^{-3} $[Fe^{3+}]$ = 1.05 × 10^{-2} / 0.015 mol dm^{-3} $[Fe^{2+}]$ = 4.5 × 10^{-3} / 0.0045 mol dm^{-3} $[I_2]$ = 2.25 × 10^{-3} / 0.00225 mol dm^{-3} M5 $\frac{(4.5 \times 10^{-3})^2 \times 2.25 \times 10^{-3}}{(1.05 \times 10^{-2})^2 \times (3 \times 10^{-3})^2} = 45.9$ (45.9 = 5 marks) If wrong K_c expression then ECF from 4.1 M6 Correct units scores irrespective of anything else; otherwise units should match K_c expression used in M5; if K_c expression not used in M5, then ECF from 4.1 459 = M1, M2, M3 & M5 if mole not concs used 562.5 = M2 to M5 if M1 Fe^{3+} = 7.5 x 10^{-4}	6 (6 x AO2)

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidelines</th><th>Mark</th></tr>
<tr>
<td>05.1</td>
<td>
This question is marked using Levels of Response. Refer to the Mark Scheme Instructions for Examiners for guidance.
<table>
<tr><td>Level 3
5–6 marks</td><td>All stages are covered and the explanation of each stage is correct and virtually complete

Answer communicates the whole explanation, including equations, coherently and shows a logical progression through all three stages.</td></tr>
<tr><td>Level 2
3–4 marks</td><td>All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies.
OR
two stages covered and the explanations are generally correct and virtually complete.

Answer is coherent and shows some progression through all three stages. Some steps in each stage may be incomplete.</td></tr>
<tr><td>Level 1
1–2 marks</td><td>Two stages are covered but the explanation 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 shows some progression between two stages.</td></tr>
<tr><td>0 mark</td><td>Insufficient correct chemistry to gain a mark.</td></tr>
</table>
</td>
<td>
Stage 1: Oxidation of the alcohols
(covered = 1/3; virtually complete = 2/3)

1a – use acidified potassium dichromate(VI) to oxidise both samples

1b – $CH_3CH_2CH_2OH + [O] \rightarrow CH_3CH_2CHO + H_2O$

1c – $CH_3CH(OH)CH_3 + [O] \rightarrow CH_3COCH_3 + H_2O$
NOT molecular formulae

Stage 2: Testing the aldehyde/ketone formed by the oxidation
(covered = 1/3; virtually complete = 2/3)

2a – test both samples using Fehling’s solution / Tollens’ reagent / acidified potassium dichromate(VI)

2b – propanal (or product of oxidation of propan-1-ol) will form brick red precipitate / silver mirror / (orange to) green (solution)

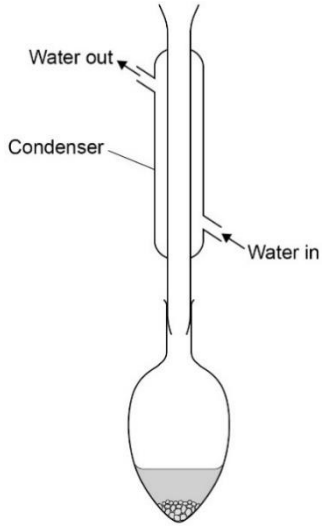
2c – propanone (or product of oxidation of propan-2-ol) will have no visible change / no reaction

Stage 3: Use of IR spectroscopy
(covered = 1/3; virtually complete = 2/3)

3a – Both show absorption at 3230-3550 (for O–H alcohol)

3b – use the <u>fingerprint region</u> of each sample

3c – find an (exact) match to a database / idea that fingerprint region is unique to an individual compound
</td>
<td>6
(6 x AO3)</td>
</tr>
</table>

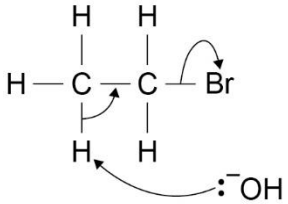
Question	Answers	Additional comments/Guidelines	Mark
05.2	 M1 Condition = (heat under) reflux M2 Must have a vertical condenser open at the very top **AND** no gap between the pear-shaped flask and the condenser M3 Minimum labels must be water in, water out (or arrows) and condenser	**ALLOW** heat/boil if diagram looks like reflux **NOT** ECF to incorrect diagram **NOT** lines across water in/out tubes (that would seal openings) **NOT** lines across the condenser at any height (that would seal off the reaction mixture) **NOT** thermometer drawn anywhere in diagram	3 (1 x AO1, 2 x AO3)

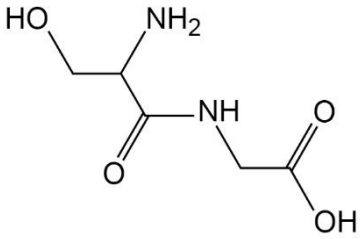
Question	Answers	Additional comments/Guidelines	Mark
05.3	To produce (a steady stream of) tiny/small(er) bubbles **OR** To prevent large bubbles	**IGNORE** "to prevent bumping"	1 (1 x AO1)

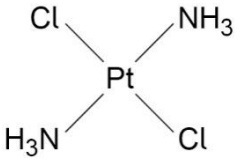
Question	Answers	Additional comments/Guidelines	Mark
06.1	*E-Z* (isomerism)	**ALLOW** Z / geometric / cis-trans / cis	1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
06.2	M1 9 M2 four M3 biodiesel / biofuel		3 (1 x AO1, 2 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
06.3	M1 $C_{18}H_{31}O_2Na$ / $C_{17}H_{31}COONa$ M2 soaps / anionic surfactant	**ALLOW** $C_{18}H_{31}O_2^-$ / $C_{17}H_{31}COO^-$ **ALLOW** any unambiguous formula/structure **ALLOW** CHCH for CH=CH in structural formula **NOT** O–Na i.e. covalent bond between O & Na **NOT** cationic surfactant / detergents / shampoo	2 (1 x AO1, 1 x AO2)

Question	Marking Guidance	Mark	Comments
07	B	1 (AO2)	$(C_2H_5)_3N^+CH_3$
08	D	1 (AO3)	CH_3Br to CH_3OH
09	C	1 (AO1)	The rate of the reverse reaction increases.
10	B	1 (AO1)	
11	A	1 (AO1)	**A** | Na_2O MgO Al_2O_3 | SiO_2 | P_4O_{10} SO_3
12	A	1 (AO2)	19
13	D	1 (AO2)	Propene
14	B	1 (AO1)	Colourless solution and effervescence
15	B	1 (AO1)	Atomic radius decreases.
16	C	1 (AO1)	The first ionisation energy of P is less than that of S
17	C	1 (AO3)	Optical only
18	C	1 (AO1)	$CH_3CHClCH=C(CH_3)COOH$

19	D	1 (AO1)	SO_3
20	A	1 (AO1)	Atomic radius
21	C	1 (AO1)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^3$
22	A	1 (AO1)	Tollens' reagent contains linear $[Ag(NH_3)_2]^+$ ions.
23	A	1 (AO1)	The addition of excess aqueous ammonia to a solution containing $[Co(H_2O)_6]^{2+}$ ions.
24	D	1 (AO1)	It is anaerobic and the ethanol is separated by fractional distillation
25	B	1 (AO1)	Radon
26	C	1 (AO2)	A solution of hydrochloric acid containing 6 mol of HCl reacts completely with 1 mol of Al_2O_3
27	B	1 (AO2)	$FeCl_4^-$
28	A	1 (AO1)	Alkanes obtained are converted to alkenes by thermal cracking.
29	C	1 (AO2)	
30	D	1 (AO1)	sodium magnesium chlorine

31	C	1 (AO1)	<table><tr><td>**C**</td><td>tetrahedral</td><td>pyramidal</td></tr></table>
32	B	1 (AO1)	
33	C	1 (AO2)	**U** and **V**
34	B	1 (AO1)	Enzymes are polymers.
35	A	1 (AO1)	$[C_{16}H_{33}N(CH_3)_3]Br$
36	A	1 (AO2)