AQA

A-LEVEL
Chemistry

7405/3 - Paper 3

Mark scheme

June 2018

Version/Stage: 1.1 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 Assessment Writer.

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.

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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 (i.e. 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 (e.g. 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.

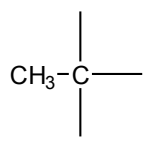
3.12 Organic structures

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.

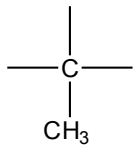
In general

- 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, e.g 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.

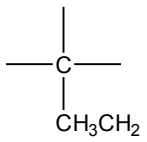
By way of illustration, the following would apply.



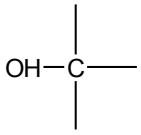
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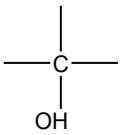
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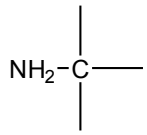
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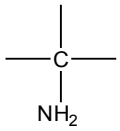
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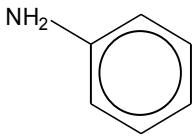
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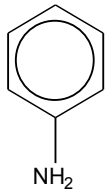
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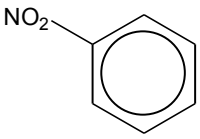
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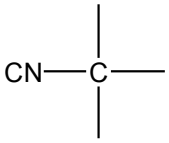
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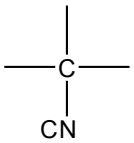
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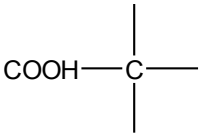
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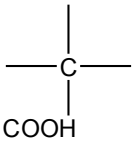
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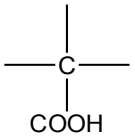
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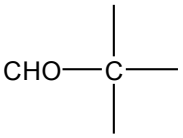
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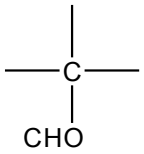
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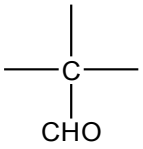
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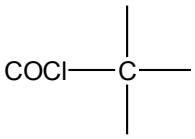
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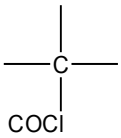
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- Representation of CH_2 by $C{-}H_2$ will be penalised
- Some examples are given here of **structures** for specific compounds that should **not** gain credit (but, exceptions may be made in the context of balancing equations)

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 (e.g. 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.

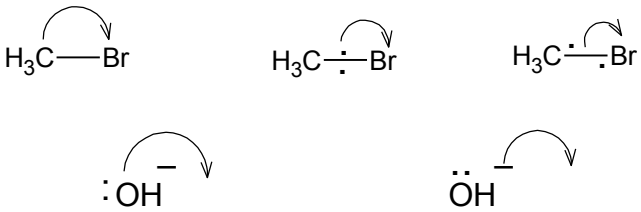
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

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**

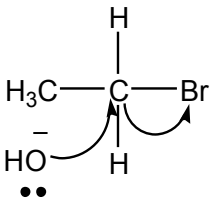
3.14 Organic reaction mechanisms

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.

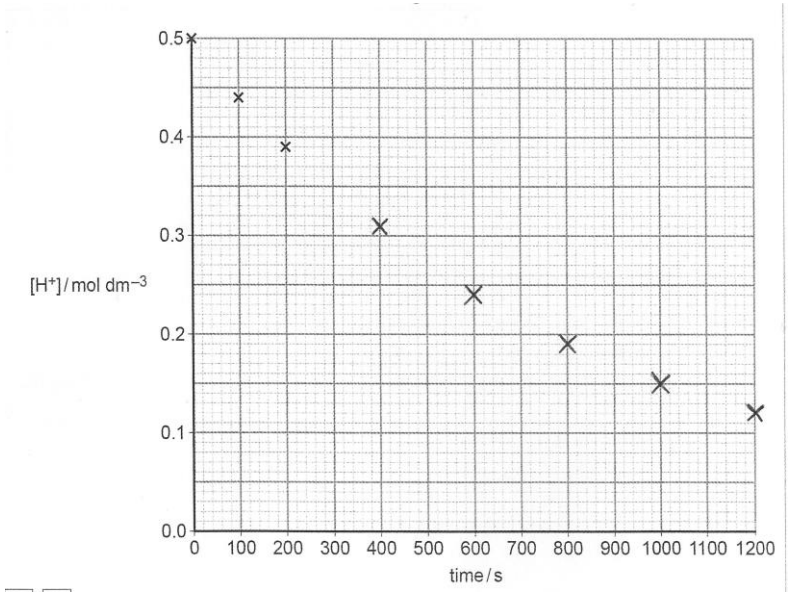
An answer which contains nothing of relevance to the question must be awarded no marks.

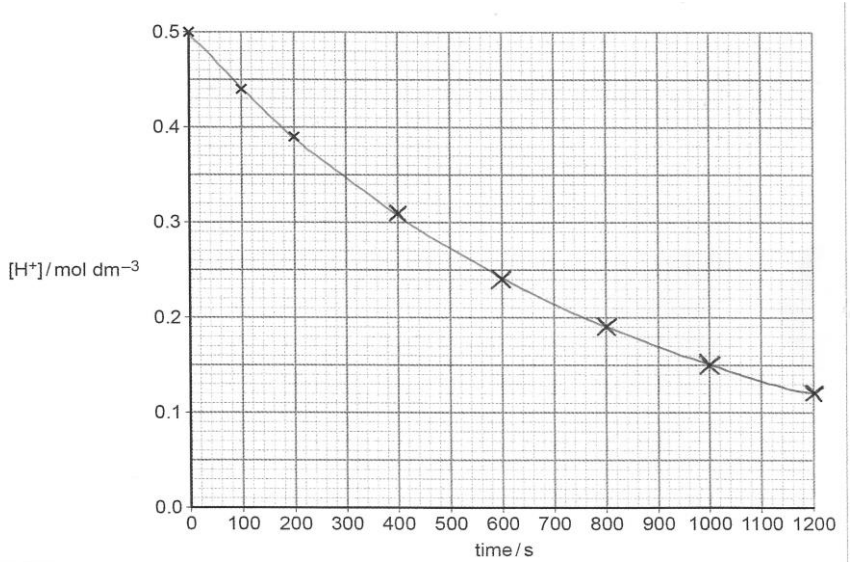
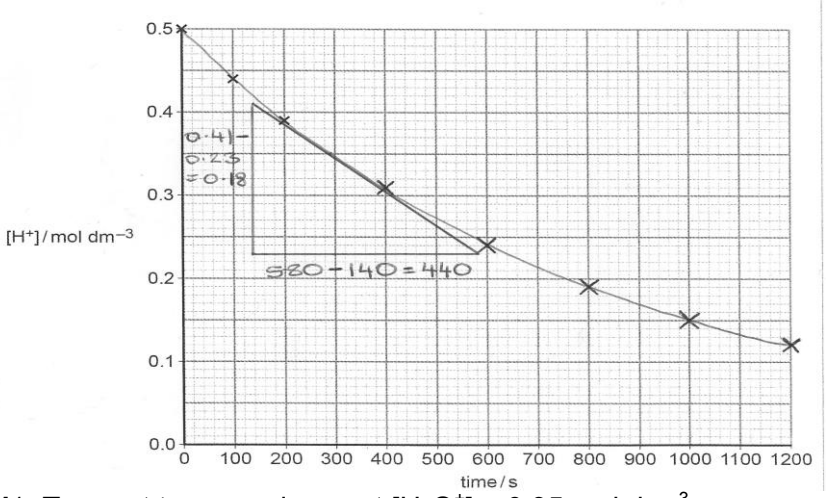
For other extended response answers:

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	H_2O_2 and/or I^- <u>concentration</u> change is negligible / H_2O_2 and/or I^- <u>concentration</u> (effectively) constant so have a constant/no effect on the rate / so is zero order (w.r.t. H_2O_2 and I^-) / a and b are zero	<u>Only</u> the <u>concentration</u> of H^+ changes. Ignore references to H^+ is limiting reagent / rds / H_2O_2/I^- not in rate equation Do not allow reference to catalyst.	2
01.2	Stop the reaction / quench By dilution / cooling / adding a reagent to react with H_2O_2/I^-	Allow valid suggestions about how to stop the reaction. Do not allow reaction with acid/alkali / neutralisation for M2 Do not penalise other named reagents. Ignore references to measuring volume and adding indicator	2
01.3	M1: constant gradient OR <u>change/decrease</u> in concentration is proportional to time M2: as $[H^+]$ changes/decreases	Allow constant rate / rate = *k* Ignore reference to straight line Not increase in concentration / concentration is inversely proportional / concentration (on its own) is proportional M2 dependent on correct M1 Allow rate v concentration graph would give horizontal straight line owtte Allow so $[H^+]$ has no effect on the rate	2

01.4	evidence of attempt at calculation of gradient via $\Delta y/\Delta x$ k_1 = 0.0012 / 1.2 x 10^{-3} units = <u>mol dm^{-3} s^{-1}</u>	allow construction lines on graph At least 2 sf (0.00118 – 0.00122) Correct answer scores 2/2 No ecf from incorrect or inverted numbers in M1 k_1 = – 0.0012 scores 1/2 Additional processing of data such as including $[H^+]$ loses M2 M3 mark independently	3
01.5	5 points correctly plotted  	Allow ±half a small square for each point	1

01.6		Smooth curve only within one small square of all points (ecf on 01.5) Not a series of straight lines between points	1
01.7	 M1: Tangent to curve drawn at $[H_3O^+]$ = 0.35 mol dm^{-3} e.g. 0.18/440 M2: Rate = 4.09 x 10^{-4} (mol dm^{-3} s^{-1})	M1 for a tangent / triangle / other suitable working Allow ECF for both M1 and M2 following on from straight line drawn in 01.6, but must show suitable construction on graph for M1 Ignore negative signs Allow value in range 3.70 x 10^{-4} - 4.50 x 10^{-4} At least 2sf ecf from any straight line for correctly calculated gradient	2

<table>
<tr>
<td>01.8</td>
<td>This question is marked using levels of response. Refer to the Mark Scheme Instructions for examiners for guidance on how to mark this question
<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 is coherent and shows progression through all three stages.

A clear explanation of how the order is determined from the results is needed to show coherence.</td></tr>
<tr><td>Level 2

3-4 marks</td><td>All stages are covered (NB ‘covered’ means min 2 from stage 2) 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 out of order and 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>Level 0

0 marks</td><td>Insufficient correct Chemistry to warrant a mark</td></tr>
</table>
</td>
<td>Indicative Chemistry content Method 1

Stage 1 Preparation

1a Measure (suitable/known volumes of) some reagents (ignore quoted values for volume)
1b Measure (known amount of) X / use a colorimeter
1c into separate container(s) – (allow up to two reagents and X measured together into one container); reference to A, B or C added last. NOT if X added last.

Stage 2 Procedure

2a Start clock/timer at the point of mixing (don’t allow if only 2 reagents mixed)
(allow even if X not added or added last)l
2b Time recorded for appearance of blue colour/specific reading on colorimeter/disappearing cross
2c Use of same concentration of B and C / same total volume / same volume/amount of X
2d Same temperature/use water bath
2e Repeat with different concentrations of A (can be implied through different volumes of A and same total volume)

Stage 3 Use of Results

3a 1/time taken is a measure of the rate
3b plot of 1/time against volumes/concentrations of A or plot log(1/time) vs log(volume or concentration of A)
3c description of interpreting order from shape of 1/time vs volume or concentration graph / gradient of log plot gives order / allow interpretation of time vs concentration graph / ratio between change in concentration and change in rate (e.g, 2x[A] = 2 x rate so 1st order)</td>
<td>6</td>
</tr>
</table>

Total			19

Indicative Chemistry content – Alternative Method Using Colorimetry and repeated Continuous Monitoring

Stage 1 Preparation

1a Measure (suitable/known volumes of) **A**, **B** and **C** (ignore quoted values for volume)
1b Use of colorimeter
1c into separate container(s) – (allow up to two reagents measured together into one container) – ignore use of X

Stage 2 Procedure

2a Start clock/timer at the point of mixing
2b Take series of colorimeter readings at regular time intervals
2c Use of same concentration of **B** and **C** / same total volume / (same volume/amount of **X)**
2d Same temperature
2e Repeat with different concentrations of **A** (can be implied through different volumes of **A** and same total volume)

Stage 3 Use of Results

3a Plot absorbance vs time and measure/calculate gradient at time=0
3b plot of gradient against volumes/concentrations of **A** or plot log(1/time) vs log(volume or concentration of **A**)
3c description of interpreting order from shape of 1/time vs volume or concentration graph / gradient of log plot gives order

Question	Answers	Additional Comments/Guidelines	Mark
02.1	$4Na + O_2 \rightarrow 2Na_2O$	Ignore state symbols Allow multiples and fractions Allow $2Na + O_2 \rightarrow Na_2O_2$	1
	Yellow/orange flame/light AND white solid/powder/smoke/fumes/ash	Allow yellow solid Do not allow ppt. Apply list principle Ignore formulae in observations	1
02.2	$4P + 5O_2 \rightarrow P_4O_{10}$ / $P_4 + 5O_2 \rightarrow P_4O_{10}$	Ignore state symbols Do not allow equations with P_2O_5 Allow $4P + 3O_2 \rightarrow P_4O_6$ / $P_4 + 3O_2 \rightarrow P_4O_6$	1 1
	white flame/light OR white fumes/smoke/solid/powder/ash	Do not allow ppt. Apply list principle	
02.3	Greater/increased charge/charge density on magnesium ion/Mg^{2+} (specific mention of <u>ion(s)</u> can be scored from M2)	Allow magnesium <u>ion</u> is smaller (than sodium ion); Ignore atomic radius If mention of molecules, intermolecular forces, metallic bonding then CE=0	1
	Stronger attraction for <u>anions</u>/oxide <u>ion</u> / stronger attraction between oppositely charged <u>ions</u>/ stronger attraction between Mg^{2+} and O^{2-} / stronger <u>ionic</u> bonding	Ignore references to covalent character Mark independently	1

02.4	(SiO_2) giant covalent / macromolecular (P_4O_{10}) (simple) molecular (Covalent) bonds (throughout structure) of SiO_2 much stronger than the <u>forces between molecules/intermolecular forces</u> in P_4O_{10}	Do not allow M1 and M2 if it is clear that the candidate is referring to the structure of the elements rather than the oxides. M3 could score from correct comparison of giant covalent to simple molecular Allow giant molecule Not simple covalent Reference to 'between molecules' in M3 would also get M2 Allow van der Waals' forces between molecules M3 dependent on correct M1 <u>and</u> M2	1 1 1
02.5	M1: Sample in suitable melting point apparatus (e.g. capillary in oil bath/Thiele tube / melting point apparatus) M2: Heat slowly/gradually/gently (to establish melting point range) M3: Lower melting point / (broad) range of melting point indicates presence of impurities OR melting point agrees with/close to data book value / melts sharply/over narrow range / melting point exactly 573K indicates purity	Do not allow water bath	1 1 1

Total			12

Question	Answers	Additional Comments/Guidelines	Mark
03.1	M1: Moles of cyclohexanol = (10 x 0.96)/100.0 = 0.096 M2: Max mass of cyclohexene = 0.096 x 82.0 = 7.87(2) M3: % yield = (5.97 / 7.87) x 100 = 76% (Allow range 75.8 – 76) Alternative method M1: Moles of cyclohexanol = (10 x 0.96)/100.0 = 0.096 M2: Moles of cyclohexene = 5.97/82.0 = 0.0728 M3: % yield = 0.0728 / 0.096 x 100 = 76% (allow range 75.8 – 76)	Correct answer scores all 3 marks = M1 x 82.0 (process mark) = (5.97 / M2) x 100 (process mark) = (M2 / M1) x 100 Allow 1/3 for 62(.2)%	1 1 1
03.2	Add bromine (water) Would turn (from orange to) colourless / decolourise	If M1 not correct then only allow M2 if reagent involves bromine (water) Do not allow incorrect starting colour, but allow brown/red/yellow Not discolour. Ignore clear	1 1
03.3	Na_2CO_3 would neutralise/react with/remove (phosphoric) acid/H_3PO_4/H^+		1
03.4	avoid pressure build-up / release pressure / release CO_2/air/gas / prevent stopper blowing out	Ignore explosion Do not allow an incorrect named gas Allow idea that build-up of gas/CO_2 would lead to increased pressure/stated effect of increased pressure	1

03.5	Does not dissolve in/react with the cyclohexene	Allow remains a solid/is inert in cyclohexene Allow organic product/organic compound formed/ organic layer/distillate instead of cyclohexene Do not allow if answer implies cyclohexanol Do not allow if answer says does not react with products Ignore references to filtration Do not allow insoluble/unreactive unless qualified by implied reference to cyclohexene	1
03.6	If diagram drawn: M1: diagram of basic set up to include flask or tube with side-arm/Buchner flask, flat-bottomed funnel/Buchner funnel, filter paper M2: apparatus should work, flow through, air-tight connection between flask and funnel, arrow/label/description (to vacuum pump) If description given: M1: Buchner funnel/flat-bottomed funnel containing filter paper M2: Buchner flask/side-arm flask connected to vacuum pump	Do not allow "standard" Y-shaped funnel Do not allow just "funnel" Penalise M2 if described apparatus would not actually work.	1 1
03.7	Cyclohexene is less polar than cyclohexanol / cyclohexanol is more polar than cyclohexene Cyclohexene has a greater affinity/attraction for the mobile phase/hexane / cyclohexanol has a greater affinity/attraction for the stationary phase/silica	It = cylcohexene Allow cyclohexene is non-polar <u>and</u> cyclohexanol is polar Allow cyclohexanol held in the stationary phase for longer Allow cyclohexene is more soluble in the mobile phase/hexane or converse for cyclohexanol Allow references to hydrogen bonds between cylcohexanol and silica	1 1

03.8	Would be no peak at 3230 – 3550 cm^{-1} due to O—H((alcohol)) OR There would be no additional peaks in the fingerprint region compared to a pure sample / fingerprint region exactly matches cylcohexene	Need wavenumber and bond for mark	1

Total			13

Question	Answers	Additional Comments/Guidelines	Mark
04.1	M1: Temperature on the y-axis and uses sensible scales (i.e. minimum 20 little squares for each °C on y-axis)	Lose mark if temperature scale starts at 0°C This mark scores if all points fit on the grid. Do not penalise M1 if extrapolation to 4 mins goes off the grid – this is penalised in M3.	1
	M2: Plots all the points correctly (± half a small square)	Lose mark if the points go off the grid Ignore a plotted point at 4 mins used to work out ΔT	1
	M3: Draws two best fit lines (0-3 mins) and (6-12 mins)	Both lines must be straight and through all points except 5th minute; lose mark if the lines are kinked/doubled. Any line through 5th minute loses mark "S-shaped curve" through points loses M3 and M4	1
	M4: Extrapolates both lines to at least the 4th minute	Lose mark if the extrapolation goes off the grid.	1
	M5: 21.9 – 19.8 = 2.1 (°C)	Allow calculation of ΔT from S-shaped curve as: Value at 4th minute – 19.8 but not if 0 (°C) ΔT value ecf from incorrect lines/extrapolation ΔT must be to at least 1dp If value of ΔT = 2.1, then award M5	1
04.2	0.2 / 2.1 x 100 = 9.5 %	Conseq on 04.1 Ignore no of sfs.	1
04.3	Replace the glass beaker with a polystyrene cup **/** insulate the glass beaker / use a lid	Ignore use more dilute solutions Ignore suggested materials for insulation Do not allow copper calorimeter / bomb calorimeter	1
04.4	Increase magnitude of temperature change	Ignore references to volume changes	1
	by increasing the <u>concentration</u> of the acid/alkali	Mark independently	1

04.5	$HOOCCOOH + 2KOH \rightarrow K_2(OOCCOO) + 2H_2O$	M1 – equation (allow ionic KOH / $K_2C_2O_4$) $H_2C_2O_4 + 2KOH \rightarrow K_2C_2O_4 + 2H_2O$ ignore state symbols allow multiples Mark independently	
	q (= mc∆T) = 100 x 4.2 x 3.2 = 1344 J	M2 – process (ignore sign here) (allow calculations involving 4.18 which leads to 1338 J)	1
	n HOOCCOOH = 25 x 0.800 / 1000 = <u>0.020</u> n KOH = 75 x 0.6 / 1000 = <u>0.045</u>	M3 – calculations of amounts, in moles, of both the ethanedioic acid and potassium hydroxide (both calculations needed)	1
	Moles of water = <u>0.040</u> moles	M4 – answer (stated or used in calculation of ∆H)	1
	∆H = –1.344/0.04 = – 33.6 (kJ mol^{-1})	M5 – ecf on M2 and M4 Answer must be negative and to at least 2sf ∆H = – M2 (in kJ) / M4 –32.5 - –34 scores 4/4 (M2-M5 + equation) +32.5 - +34 scores 3/4 (M2, M3, M4 + equation) –65 - –68 scores 3/4 (+ equation) +65 - +68 scores 2/4 (+ equation) –52 - –54 scores 3/4 (+ equation) +52 - +54 scores 2/4 (+ equation)	2

04.6	HOOCCOOH is a weak acid / not fully dissociated (more) <u>energy</u> needed to break bonds/complete dissociation / dissociation is endothermic	H_2SO_4 is a strong(er)acid / fully dissociated / dissociates more So less energy is needed for dissociation of sulfuric acid Ignore references to heat loss	1 1

Total			16

Question	Marking Guidance
05	A
06	A
07	D
08	A
09	D
10	D
11	A
12	C
13	D
14	A
15	D
16	C
17	A
18	A
19	C

Question	Marking Guidance
20	D
21	C
22	B
23	A
24	C
25	A
26	C
27	B & C
28	B
29	B
30	B
31	B
32	B
33	D
34	C