AQA

A-level
CHEMISTRY
7405/1

Paper 1 Inorganic and Physical Chemistry

Mark scheme

June 2021

Version: 1.0 Final

216A74051/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.

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AS and A-Level Chemistry
Mark Scheme Instructions for Examiners

1. General

The mark scheme for each question shows:

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

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

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

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

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

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

2. Emboldening

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

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

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

3. Marking points

3.1 Marking of lists

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

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

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

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

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

3.2 Marking procedure for calculations

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

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

3.3 Errors carried forward, consequential marking and arithmetic errors

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

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

3.4 Equations

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

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

3.5 Oxidation states

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

3.6 Interpretation of 'it'

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

3.7 Phonetic spelling

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

3.8 Brackets

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

3.9 Ignore / Insufficient / Do <u>not</u> allow

Ignore or insufficient is used when the information given is irrelevant to the question or not enough to gain the marking point. Any further correct amplification could gain the marking point.

Do **not** allow means that this is a wrong answer which, even if the correct answer is given, will still mean that the mark is not awarded.

3.10 Marking crossed out work

Crossed out work that **has not been** replaced should be marked as if it were not crossed out, if possible. Where crossed out work **has been** replaced, the replacement work and not the crossed out work should be marked.

3.11 Reagents

The command word 'Identify', allows the student to choose to use **either** the name **or** the formula of a reagent in their answer. In some circumstances, the list principle may apply when both the name and the formula are used. Specific details will be given in mark schemes.

The guiding principle is that a reagent is a chemical which can be taken out of a bottle or container. Failure to identify complete reagents **will be penalised**, but follow-on marks (eg for a subsequent equation or observation) can be scored from an incorrect attempt (possibly an incomplete reagent) at the correct reagent. Specific details will be given in mark schemes.

For example, **no credit** would be given for:

- the cyanide ion or CN^- when the reagent should be potassium cyanide or KCN;
- the hydroxide ion or OH^- when the reagent should be sodium hydroxide or NaOH;
- the $Ag(NH_3)_2^+$ ion when the reagent should be Tollens' reagent (or ammoniacal silver nitrate). In this example, no credit is given for the ion, but credit could be given for a correct observation following on from the use of the ion. Specific details will be given in mark schemes.

In the event that a student provides, for example, **both** KCN and cyanide ion, it would be usual to ignore the reference to the cyanide ion (because this is not contradictory) and credit the KCN. Specific details will be given in mark schemes.

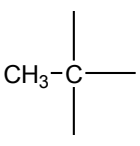
3.12 Organic structures

Where students are asked to draw organic structures, unless a specific type is required in the question and stated in the mark scheme, these may be given as displayed, structural or skeletal formulas or a combination of all three as long as the result is unambiguous.

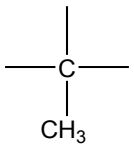
In general

- Displayed formulae must show all of the bonds and all of the atoms in the molecule, but need not show correct bond angles.
- Skeletal formulae must show carbon atoms by an angle or suitable intersection in the skeleton chain. Functional groups must be shown and it is essential that all atoms other than C atoms are shown in these (except H atoms in the functional groups of aldehydes, secondary amines and N-substituted amides which do not need to be shown).
- Structures must not be ambiguous, e.g. 1-bromopropane should be shown as $CH_3CH_2CH_2Br$ and not as the molecular formula C_3H_7Br which could also represent the isomeric 2-bromopropane.
- Bonds should be drawn correctly between the relevant atoms. This principle applies in all cases where the attached functional group contains a carbon atom, eg nitrile, carboxylic acid, aldehyde and acid chloride. The carbon-carbon bond should be clearly shown. Wrongly bonded atoms will be penalised **on every occasion**. (see the examples below)
- The same principle should also be applied to the structure of alcohols. For example, if students show the alcohol functional group as C ─ HO, they should be penalised **on every occasion**.
- Latitude should be given to the representation of C ─ C bonds in alkyl groups, given that CH_3─ is considered to be interchangeable with H_3C─ even though the latter would be preferred.
- Similar latitude should be given to the representation of amines where NH_2─ C will be allowed, although H_2N─ C would be preferred.
- Poor presentation of vertical C ─ CH_3 bonds or vertical C ─ NH_2 bonds should **not** be penalised. For other functional groups, such as ─ OH and ─ CN, the limit of tolerance is the half-way position between the vertical bond and the relevant atoms in the attached group.

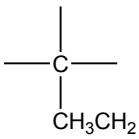
By way of illustration, the following would apply.



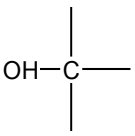
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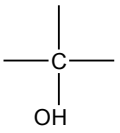
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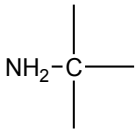
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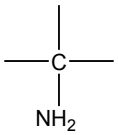
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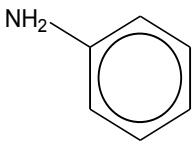
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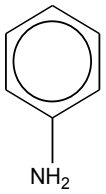
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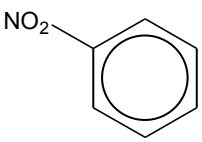
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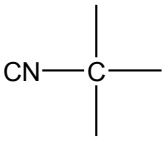
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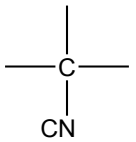
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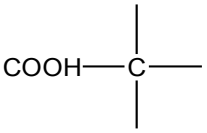
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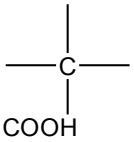
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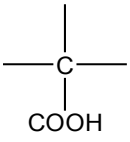
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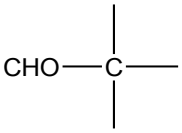
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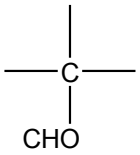
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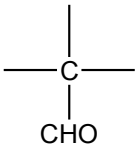
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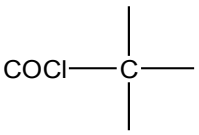
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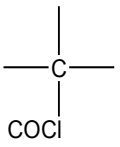
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- Representation of CH_2 by $C{-}H_2$ will be penalised
- Some examples are given here of **structures** for specific compounds that should **not** gain credit (but, exceptions **may** be made in the context of balancing equations)

CH_3COH	for	ethanal
CH_3CH_2HO	for	ethanol
$OHCH_2CH_3$	for	ethanol
C_2H_6O	for	ethanol
CH_2CH_2	for	ethene
$CH_2.CH_2$	for	ethene
$CH_2{:}CH_2$	for	ethene

- Each of the following **should gain credit** as alternatives to correct representations of the structures.

$CH_2 = CH_2$	for	ethene, $H_2C{=}CH_2$
$CH_3CHOHCH_3$	for	propan-2-ol, $CH_3CH(OH)CH_3$

- In most cases, the use of 'sticks' to represent C ─ H bonds in a structure should **not** be penalised. The exceptions to this when "sticks" will be penalised include
  - structures in mechanisms where the C ─ H bond is essential (eg elimination reactions in halogenoalkanes and alcohols)
  - when a displayed formula is required
  - when a skeletal structure is required or has been drawn by the candidate.

3.13 Organic names

As a general principle, non-IUPAC names or incorrect spelling or incomplete names should **not** gain credit. Some illustrations are given here.

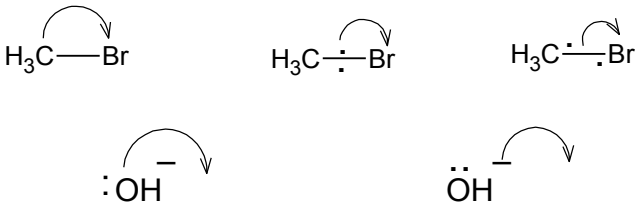
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

but-2-ol	should be **butan-2-ol**
2-hydroxybutane	should be **butan-2-ol**
butane-2-ol	should be **butan-2-ol**
2-butanol	should be **butan-2-ol**
ethan-1,2-diol	should be **ethane-1,2-diol**
2-methpropan-2-ol	should be **2-methylpropan-2-ol**
2-methylbutan-3-ol	should be **3-methylbutan-2-ol**
3-methylpentan	should be **3-methylpentane**
3-mythylpentane	should be **3-methylpentane**
3-methypentane	should be **3-methylpentane**
propanitrile	should be **propanenitrile**
aminethane	should be **ethylamine** (although aminoethane can gain credit)
2-methyl-3-bromobutane	should be **2-bromo-3-methylbutane**
3-bromo-2-methylbutane	should be **2-bromo-3-methylbutane**
3-methyl-2-bromobutane	should be **2-bromo-3-methylbutane**
2-methylbut-3-ene	should be **3-methylbut-1-ene**
difluorodichloromethane	should be **dichlorodifluoromethane**

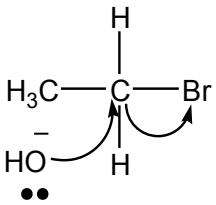
3.14 Organic reaction mechanisms

Curly arrows should originate either from a lone pair of electrons or from a bond.

The following representations should not gain credit **and will be penalised each time** within a clip.



For example, the following would score zero marks



When the curly arrow is showing the formation of a bond to an atom, the arrow can go directly to the relevant atom, alongside the relevant atom or **more than half-way** towards the relevant atom.

In free-radical substitution:

- the absence of a radical dot should be penalised **once only** within a clip.
- the use of half-headed arrows is not required, but the use of double-headed arrows or the incorrect use of half-headed arrows in free-radical mechanisms should be penalised **once only** within a clip.

The correct use of skeletal formulae in mechanisms is acceptable, but where a C-H bond breaks, both the bond and the H must be drawn to gain credit.

3.15 Extended responses

For questions marked using a 'Levels of Response' mark scheme:

Level of response mark schemes are broken down into three levels, each of which has a descriptor. Each descriptor contains two statements. The first statement is the Chemistry content statement and the second statement is the communication statement.

Determining a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the Chemistry content descriptor for that level. The descriptor for the level indicates the qualities that might be seen in the student's answer for that level. If it meets the lowest level, then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level.

Once the level has been decided, the mark within the level is determined by the communication statement:

• If the answer completely matches the communication descriptor, award the higher mark within the level.

• If the answer does not completely match the communication descriptor, award the lower mark within the level.

The exemplar materials used during standardisation will help you to determine the appropriate level. There will be an exemplar in the standardising materials which will correspond with each level of the mark scheme and for each mark within each level. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the exemplar to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the exemplar.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other chemically valid points. Students may not have to cover all of the points mentioned in the indicative content to reach the highest level of the mark scheme. The mark scheme will state how much chemical content is required for the highest level.

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

For other extended response answers:

Where a mark scheme includes linkage words (such as 'therefore', 'so', 'because' etc), these are optional. However, a student's marks for the question may be limited if they do not demonstrate the ability to construct and develop a sustained line of reasoning which is coherent, relevant, substantiated and logically structured. In particular answers in the form of bullet pointed lists may not be awarded full marks if there is no indication of logical flow between each point or if points are in an illogical order.

The mark schemes for some questions state that the maximum mark available for an extended response answer is limited if the answer is not coherent, relevant, substantiated and logically structured. During the standardisation process, the Lead Examiner will provide marked exemplar material to demonstrate answers which have not met these criteria. You should use these exemplars as a comparison when marking student answers.

Question	Answers	Additional comments/Guidelines	Mark
01.1	Heat (energy) change at constant pressure	Ignore conditions even if wrong Ignore energy change	1

Question	Answers	Additional comments/Guidelines	Mark
01.2	M2 $Ca^{2+}(g) + 2\ e^- + Cl_2(g)$	Alternative M2 $Ca^+(g) + e^- + 2\ Cl(g)$	1
	M3 $Ca^{2+}(g) + 2\ Cl^-(g)$		1
	M1 $Ca(s) + Cl_2(g)$		1

Question	Answers	Additional comments/Guidelines	Mark
01.3	M1 $-795 + LE = 193 + 590 + 1150 + (\mathbf{2} \times 121) + (\mathbf{2} \times -364)$	Numbers and factors used correctly from cycle	1
	M2 $LE = (+)\ 2242\ (kJ\ mol^{-1})$	Rearrangement to calculate LE If one or both factors of 2 missing award 1 mark for (+) 2485, (+)2121 or (+)2606 ($kJ\ mol^{-1}$) Allow 1 mark for – 2242 ($kJ\ mol^{-1}$)	1

Question	Answers	Additional comments/Guidelines	Mark
01.4	$MgCl_2(s) \rightarrow Mg^{2+}(aq) + 2\ Cl^-(aq)$	Allow $MgCl_2(s) \rightleftharpoons Mg^{2+}(aq) + 2\ Cl^-(aq)$ Allow $MgCl_2(s) + aq \rightleftharpoons Mg^{2+}(aq) + 2\ Cl^-(aq)$	1

Question	Answers	Additional comments/Guidelines	Mark
01.5	M1 ΔH soln $MgCl_2$ = ΔH latt diss+ ΔH hyd Mg^{2+} + **2**ΔH hyd Cl^- **OR** 2493 –1920 + (**2** x –364) M2 = – 155 (kJ mol^{-1})	M1 for expression with or without numbers M2 for answer If factor of 2 missing for ΔH hyd Cl^-, allow 1 mark for 209	1 1

Question	Answers	Additional comments/Guidelines	Mark
01.6	M1 Ca^{2+} (ion) bigger/lower charge to size ratio (than Mg^{2+}) M2 weaker attraction/bond to ($O^{\delta-}$ in) water	Allow converse answers M1 Do not accept Ca^{2+} is a bigger atom/molecule M1 Allow Ca^{2+} has more shells/ more distance of outer e to nucleus Ignore more shielding	1 1

Question	Answers	Additional comments/Guidelines	Mark
02.1	<u>Number</u> of protons + neutrons (in the nucleus of the atom)	Do not allow reference to mass or average Ignore references to C-12 being 12	1

Question	Answers	Additional comments/Guidelines	Mark
02.2	<table><tr><th></th><th>Number of protons</th><th>**Number of neutrons**</th><th>**Number of electrons**</th></tr><tr><td>^{46}Ti</td><td>22</td><td>**24**</td><td>**22**</td></tr><tr><td>$^{49}Ti^{2+}$</td><td>22</td><td>**27**</td><td>**20**</td></tr></table>	Mark as rows	1 1

Question	Answers	Additional comments/Guidelines	Mark
02.3	Let ^{49}Ti be y M1 $47.8 = \frac{(46 \times 2y) + (47 \times 2y) + (48 \times (100 - 5y)) + (49 \times y)}{100}$ $47.8 = \frac{235y + 4800 - 240y}{100}$ M2 $5y = 20$ OR $y = 4$ M3 abundance of ^{46}Ti = 8%	Allow M1 $47.8 = \frac{(46 \times 2) + (47 \times 2) + (48 \times n) + 49}{(5 + n)}$ M2 $0.2n = 4$ or $n = 20$ M3 % $^{46}Ti = \frac{2}{25} \times 100 = 8\%$	1 1 1

Question	Answers	Additional comments/Guidelines	Mark
03.1	$2\ Na(s) + 2\ H_2O(l) \rightarrow 2\ NaOH(aq) + H_2(g)$	Allow ionic equations Allow multiples	1
	Temperature will go up more **or** reactants can shoot out of the tube	Allow the mixture could explode or glass could shatter or hydrogen could ignite/is flammable Ignore reaction is exothermic/vigorous	1

Question	Answers	Additional comments/Guidelines	Mark
03.2	$P_4O_{10} + 6\ H_2O \rightarrow\ 4\ H_3PO_4$	Allow ionic equations Do not allow equations from P_2O_5	1
	Allow –1 to + 1		1

Question	Answers	Additional comments/Guidelines	Mark
03.3	M1 SiO_2 is macromolecular / giant covalent / giant molecule	Do not allow giant, giant atomic or giant ionic	1
	M2 Strong <u>covalent</u> bonds (between atoms) or <u>covalent</u> bonds need a lot of energy to be broken/overcome		1
	M3 P_4O_{10} is <u>molecular</u> or <u>simple covalent molecule</u>		1
	M4 Weak van der Waals forces <u>between molecules</u> or van der Waals forces <u>between molecules</u> break easily		1

Question	Answers	Additional comments/Guidelines	Mark
03.4	Al_2O_3 $Al_2O_3 + 3\ H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3\ H_2O$ or $Al_2O_3 + 6\ H^+ \rightarrow 2\ Al^{3+} + 3\ H_2O$		1 1

Question	Answers	Additional comments/Guidelines	Mark
03.5	$Mg(OH)_2$		1

Question	Answers	Additional comments/Guidelines	Mark
03.6	Na / sodium		1

Question	Answers	Additional comments/Guidelines	Mark
04.1	This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question. **Level 3** **5–6 marks** All stages are covered and the description of each stage is generally correct and virtually complete. Answer is communicated coherently and shows a logical progression from stage 1 to stage 2 and stage 3. **Level 2** **3–4 marks** All stages are covered but the description of each stage may be incomplete or may contain inaccuracies **OR** two stages are covered and the explanations are generally correct and virtually complete. Answer is mainly coherent and shows progression from stage 1 to stage 2 and/or stage 3. **Level 1** **1–2 marks** Two stages are covered but the description of each stage may be incomplete or may contain inaccuracies, **OR** only one stage is covered but the explanation is generally correct and virtually complete. Answer includes isolated statements and these are presented in a logical order. **Level 0** **0 marks** Insufficient correct chemistry to gain a mark.	Stage 1 1a Heterogeneous means in a different phase/state from reactants 1b Catalyst speeds up reaction and is left unchanged **OR** lowers the activation energy for the reaction Stage 2 2a Hydrogen and nitrogen/reactants adsorb onto the surface/ active sites of the iron 2b Bonds weaken/reaction takes place 2c Products desorb/leave from the surface (of the iron) Stage 3 3a Large surface area (of iron) by using powder or small pellets or support medium/mesh 3b Catalyst poisoned / sulfur poisons or binds to the catalyst 3c Active sites blocked Ignore references to temperature and pressure	6

Question	Answers	Additional comments/Guidelines	Mark
04.2	Two negative ions repel So activation energy is high $2\ Fe^{2+} + S_2O_8^{2-} \rightarrow 2\ SO_4^{2-} + 2\ Fe^{3+}$ $2\ Fe^{3+} + 2\ I^- \rightarrow 2\ Fe^{2+} + I_2$	 Ignore any state symbols given Allow multiples for both equations Allow equations in either order	1 1 1 1

Question	Answers	Additional comments/Guidelines	Mark
04.3	(Zn ions) have only one oxidation state Or Zn^{2+} is the only ion	Allow doesn't have variable oxidation state Allow cannot be oxidised to Zn^{3+} Ignore has a full d shell	1

Question	Answers	Additional comments/Guidelines	Mark
04.4	M1 Amount of Fe = 0.998 ÷ 55.8 = 0.0179 mol M2 Amount of HCl = 0.0300 mol M3 HCl is the limiting reagent M4 Amount of H_2 produced = 0.0150 mol M5 T = 303 K P = 100 000 Pa M6 $V \left(= \frac{0.0150 \times 8.31 \times 303}{100\ 000} \right) = 3.78 \times 10^{-4}\ (m^3)$	 M4 = M2÷2 M6 $V \left(= \frac{M4 \times 8.31 \times 303}{100\ 000} \right) (m^3)$	1 1 1 1 1 1

Question	Answers	Additional comments/Guidelines	Mark
04.5	$FeCO_3$ or iron(II) carbonate		1
	Green	Allow white	1

Question	Answers	Additional comments/Guidelines	Mark
04.6	$Fe(H_2O)_3(OH)_3$	Ignore square brackets if added	1
	brown		1
	$2\ [Fe(H_2O)_6]^{3+} + 3\ CO_3^{2-} \rightarrow 2\ Fe(H_2O)_3(OH)_3 + 3\ H_2O + 3\ CO_2$	Accept multiples	1

Question	Answers	Additional comments/Guidelines	Mark
04.7	M1 Fe^{3+} is smaller (than Fe^{2+}) **OR** Fe^{3+} has a greater charge **OR** Fe^{3+} has a greater charge density **OR** Fe^{3+} has a greater charge to size ratio	Penalise $Fe(H_2O)_6^{3+}$ ions once in M1 or M2	1
	M2 Fe^{3+} ions are more polarising **OR** Fe^{3+} ions polarise water molecules more		1
	M3 So more O-H bonds (in the water ligands) break **OR** more H^+ ions released **OR** weaken O-H bonds in ligands more (in the Fe^{3+} solution)	Do not allow Fe^{3+} releases $3H^+$ ions	1

Question	Answers	Additional comments/Guidelines	Mark
05.1	M1 decreases yield		1
	M2 So equilibrium shifts to side with more moles/molecules or more moles/molecules on LHS	Allow M2 independent of M1	1
	M3 So equilibrium shifts (to left side) to oppose decrease in pressure **OR** to increase pressure	Must refer to equilibrium shifting to gain maximum marks	1

Question	Answers	Additional comments/Guidelines	Mark
05.2	M1 amount SO_2 (= 0.46 – 0.18) = 0.28 mol		1
	M2 amount O_2 (= 0.25 – 0.09) = 0.16 mol		1
	M3 total amount (= 0.28 + 0.16 + 0.18) = 0.62 mol		1
	M4 partial pressure of SO_2 = $\frac{0.28}{0.62}$ x 215 = 97(.1) (kPa)	M4 = $\frac{M1}{M3}$ x 215	1

Question	Answers	Additional comments/Guidelines	Mark
05.3	M1 K_p = $\frac{(pp\ SO_3)^2}{(pp\ SO_2)^2 \times pp\ O_2}$	Penalise square brackets in M1	1
	M2 = $1.2(0) \times 10^{-2}$		1
	M3 = kPa^{-1}		1

Question	Answers	Additional comments/Guidelines	Mark
05.4	Stays the same		1

Question	Answers	Additional comments/Guidelines	Mark
06.1	$[H_2O]$ is (almost) constant	**Allow** $[H_2O]$ is (very) large in comparison (to $[H^+]$ and $[OH^-]$) **or** $[H_2O]$ is incorporated in K_w **or** $K_w = K_c[H_2O]$ **or** the equilibrium lies <u>very</u> much to the left. **Ignore** water has negligible dissociation **Ignore** $[H_2O] = 1$ or $[H_2O]$ is very small	1

Question	Answers	Additional comments/Guidelines	Mark
06.2	M1 Equilibrium is endothermic (in forward direction) M2 <u>Equilibrium</u> shifts to the RHS to minimise/oppose temperature increase	**Ignore** more H^+ and OH^- formed	1 1

Question	Answers	Additional comments/Guidelines	Mark
06.3	M1 $pH = -\log_{10}[H^+]$ M2 $[H^+] = \sqrt{5.48 \times 10^{-14}}$ $(= 2.34 \times 10^{-7})$ M3 $pH = -\log_{10} 2.34 \times 10^{-7} = \underline{6.63}$ M4 $[H^+] = [OH^-]$ **or** Dissociation of each water molecule gives one H^+ and one OH^-	M1 Allow $pH = -\log[H^+]$ M2 $[H^+]^2 = 5.48 \times 10^{-14}$ M3 $pH = -\log_{10}$ M2 M4 Allow equal amounts of H^+ and OH^-	1 1 1 1

Question	Answers	Additional comments/Guidelines	Mark
06.4	5.55	Allow 5.5 to 5.6	1

Question	Answers	Additional comments/Guidelines	Mark
06.5	Different solutions must not contaminate each other or To wash off any residual solution/substance (which could interfere with the reading)	pH of previous solution doesn't contaminate new solution Ignore to make neutral/neutralise Ignore so as not to affect concentrations	1

Question	Answers	Additional comments/Guidelines	Mark
06.6	To avoid missing the end point Or (Very little pH change per cm^3 added at start) large change in pH (near end point)		1

Question	Answers	Additional comments/Guidelines	Mark
06.7	All have a colour change/pH range within the steep/vertical part of the titration curve	Colour change/pH range between pH 3 and 11	1

Question	Answers	Additional comments/Guidelines	Mark
06.8	M1 Amount of OH^- = $36.25 \times 0.200 \div 1000 = 7.25 \times 10^{-3}$ mol **and** Amount of H^+ = $25.0 \times 0.150 \div 1000 = 3.75 \times 10^{-3}$ mol		1
	M2 Amount of excess OH^- = $7.25 \times 10^{-3} - 3.75 \times 10^{-3}$ = 3.50×10^{-3} mol		1
	M3 $[OH^-] = (3.50 \times 10^{-3}) \div (61.25 \times 10^{-3})$ (= 5.71×10^{-2} mol)	M3 $[OH^-]$ = (M2) ÷ (61.25×10^{-3})	1
	M4 $[H^+] = \underline{1.00 \times 10^{-14}} \div 5.71 \times 10^{-2} = 1.75 \times 10^{-13}$	M4 $[H^+] = 1.00 \times 10^{-14} \div$ M3	1
	M5 pH = 12.76	M5 Allow pH = 12.8 M5 pH = $-\log_{10}$(M4) Alternative Method M4 p OH = 1.24 M5 pH = 14 – 1.24 = 12.76	1

Question	Answers	Additional comments/Guidelines	Mark
07.1	CO_2 / gas is more disordered (than solid)	Allow answers based on carbon Ignore CO_2 is a gas and C is a solid	1

Question	Answers	Additional comments/Guidelines	Mark
07.2	0 K	Units essential Allow absolute zero **OR** –273 ^{o}C	1

Question	Answers	Additional comments/Guidelines	Mark
07.3	M1 ΔH = (**3** x – 394) –(–1669 x **2**)	M1 correct expression	1
	M2 = 2156 (kJ mol^{-1})	M2 if –2156 seen allow 1 mark out M1 and M2	1
	M3 ΔS = (28 x **4** + 214 x **3**) – (51 x **2** + 6 x **3**)	M3 correct expression	1
	M4 = 634 (J K^{-1}mol^{-1})	M4 if – 634 allow 1 mark from M4 and M4	1
	M5 $\Delta G = \Delta H - T\,\Delta S$ or $\Delta H = T\,\Delta S$ or $T = \Delta H \div \Delta S$	M5 expression or rearranged expression or with numbers	1
	M6 ΔS = 0.634 kJ K^{-1}mol^{-1}	M6 ΔS = M4 ÷ 1000	1
	M7 $T = \frac{2156}{0.634}$ = 3400 to 3401 (K)	M7 = M2 ÷ M6 but must be a positive answer	1

Question	Answers	Additional comments/Guidelines	Mark
08.1	(List of) electrode potentials/$E^{\ominus}$ in (numerical) order **OR** half cells/equations in (numerical) order of electrode potential/ $E^{\ominus}$	Do not allow EMF in order	1

Question	Answers	Additional comments/Guidelines	Mark
08.2	Any 2 from 298 K **or** 25 ^{o}C $[H^+]$ = 1 mol dm^{-3} 100 kPa	Ignore 1 atm	1

Question	Answers	Additional comments/Guidelines	Mark
08.3	$[Co(H_2O)_6]^{2+}$	Do not penalise absence of brackets	1

Question	Answers	Additional comments/Guidelines	Mark
08.4	$3\ VO_2^+ + 6\ H^+ + Fe + 3\ H_2O \rightarrow 3\ VO^{2+} + [Fe(H_2O)_6]^{3+}$ or $3\ VO_2^+ + 6\ H^+ + Fe \rightarrow 3\ VO^{2+} + 3\ H_2O + Fe^{3+}$ 1 mark for Fe^{3+} as product and one mark for equation.	Ignore state symbols Allow 1 mark for balanced equation that gives Fe^{2+} as product $2VO_2^+ + 4H^+ + Fe + 4H_2O \rightarrow 2VO^{2+} + [Fe(H_2O)_6]^{2+}$ or $2VO_2^+ + 4H^+ + Fe \rightarrow 2VO^{2+} + Fe^{2+} + 2H_2O$	2

Question	Answers	Additional comments/Guidelines	Mark
08.5	$E^{\ominus}$ $Co^{3+}(/Co^{2+})$ > $Fe^{3+}(/Fe^{2+})$ $[Co(H_2O)_6]^{3+}$ + $[Fe(H_2O)_6]^{2+}$→ $[Co(H_2O)_6]^{2+}$ + $[Fe(H_2O)_6]^{3+}$	Allow electrode potential for Co^{3+} greater than for Fe^{3+} **OR** 1.81 > 0.77 / EMF cell = 1.04 V Insist of reference to $E^{\ominus}$ in M1	1 1

Question	Answers	Additional comments/Guidelines	Mark
08.6	Different ligands	Penalise different concentrations/oxidation states	1

Question	Answers	Additional comments/Guidelines	Mark
09.1	Lithium would react with the electrolyte/water $E^{\ominus}$ for Li^+(/Li) more negative than for water or EMF= 2.21(V) or $E^{\ominus}$ Li^+ (/Li) < H_2O(/H_2 ,OH^-)	Allow water will oxidise Li to Li^+ or Li will reduce water to hydrogen Ignore EMF is negative	1 1

Question	Answers	Additional comments/Guidelines	Mark
09.2	0.54 – (–3.04) = <u>3.58</u> (V)		1

Question	Answers	Additional comments/Guidelines	Mark
09.3	Non-standard conditions	Allow non-aqueous conditions or different conditions	1

Question	Answers	Additional comments/Guidelines	Mark
09.4	(+) 7	Accept VII	1

Question	Answers	Additional comments/Guidelines	Mark
09.5	$Li^+ + CoO_2 + e^- \rightarrow Li^+CoO_2^-$ or $Li^+ + CoO_2 + e^- \rightarrow LiCoO_2$		1

Question	Answers	Additional comments/Guidelines	Mark
09.6	$Li \rightarrow Li^+ + e^-$		1