AQA

A-level
CHEMISTRY
7405/1
Paper 1 Inorganic and Physical Chemistry

Mark scheme

June 2019

Version: 1.0 Final

196A74051/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 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.

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 (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 and Observations

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.

- Where an observation is required, the answer must state clearly what is seen, heard or detected by smell. Statements such as 'carbon dioxide is given off' or 'barium sulfate is formed' would not gain marks as observations. Credit would be given for descriptions such as 'effervescence' or 'fizzing' or for 'white precipitate or white ppt'.
- Where relevant, 'no visible change' is an acceptable answer, but the statement 'no observation' would not gain a mark.

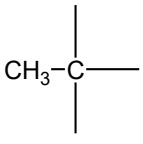
3.12 Organic structures

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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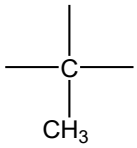

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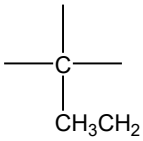

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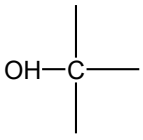

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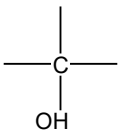

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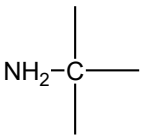

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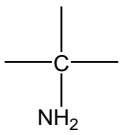

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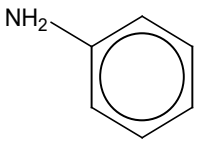

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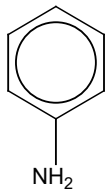

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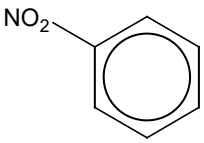

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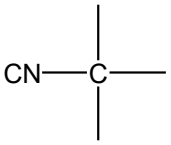

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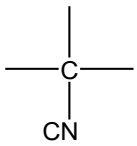

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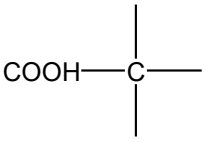

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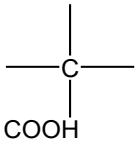

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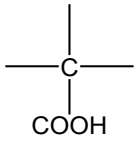

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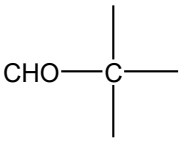

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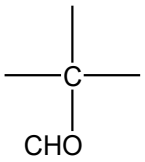

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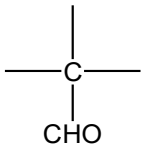

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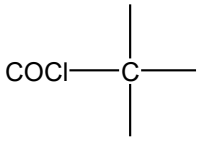

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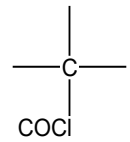


not allowed

- 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
  - 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.

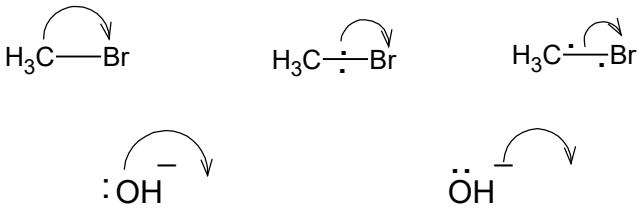
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

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**

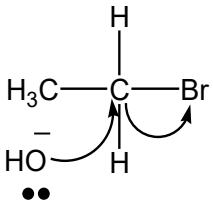
3.14 Organic reaction mechanisms

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

Mechanisms may be drawn using structural, displayed or skeletal formulae. However, if skeletal formulae are used in mechanisms such as elimination reactions (from halogenoalkanes or alcohols) or in electrophilic substitutions, any hydrogen atoms that are essential to a step in the mechanism must be shown.

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	Top line $Cs^+(g) + e^- + I(g)$ Lower line $Cs(s) + \frac{1}{2}I_2(s)$		1 1
01.2	$79 + x + 376 - 314 = -337 + 585$ So enthalpy change = 107 ($kJmol^{-1}$)	 Allow I mark for -107 ($kJmol^{-1}$) Allow answer to 2sf or more	1 1
01.3	(Almost/Mostly) purely/ perfectly ionic	If ionic not mentioned, allow no/little covalent bonding/character Penalise references to atoms/molecules Ignore electronegativity	1
01.4	M1 $\Delta S = [(82.8 + \frac{1}{2} \times 117) - 130] = \underline{11.3}$ ($J\,K^{-1}\,mol^{-1}$) M2 $\Delta G = \Delta H - T\Delta S$ M3 $\Delta G = 337 - 298 \times 11.3 \times 10^{-3}$ OR $337000 - 298 \times 11.3$ M4 ΔG = (+)334 $\underline{kJ\,mol^{-1}}$ or 334000 $\underline{J\,mol^{-1}}$	M1 Correct entropy change value M2 equation or equation with numbers M3 for converting units: ΔS into $kJK^{-1}\,mol^{-1}$ or ΔH into $Jmol^{-1}$ M4 answer with correct units Any negative answer loses M4	1 1 1 1

Question	Answers	Additional Comments/Guidelines	Mark
02.1	M1: P dissolved or put in/added to a solvent M2: (injected through) a needle or nozzle or capillary <u>and</u> at high voltage/4000 volts or high potential M3: Gains a proton / H^+ M4: $P + H^+ \rightarrow PH^+$	M1: Allow named solvent eg water or methanol M2: Allow needle is positively charged M3: Not atoms gain a proton M3: Could be scored from equation Correct equation gains M3 and M4 Ignore state symbols	1 1 1 1
02.2	555		1
02.3	M1 $V = d/t$ or $= 1.22 \times 10^5\ ms^{-1}$ M2 $m = \frac{2KE}{v^2}$ or $\frac{2 \times 2.09 \times 10^{-15}}{(1.22 \times 10^5)^2}$ or M2 $m = \frac{2KE \times t^2}{d^2}$ or $\frac{2 \times 2.09 \times 10^{-15} \times (1.23 \times 10^{-5})^2}{1.50^2}$ M3 $m = \underline{2.8(1) \times 10^{-25}}$ (kg) M4 $= 2.81 \times 10^{-25} \underline{\times L} = 0.169$ M5 $0.169 \underline{\times 1000} = 169.(2)$	Recall this equation Rearrangement to give m M3: Calculation of m. M4: Allow M3 x L M5: Allow M4 x 1000 169 only scores 5 marks Allow answers to 2 significant figures or more ignore units	1 1 1 1 1

Question	Answers	Additional Comments/Guidelines	Mark
03.1	Repeating pattern/trends (of physical or chemical properties/reactions)	Allow named property Penalise groups	1
03.2	Bromine/Br	Not Br_2 Accept Kr or Krypton	1
03.3	Potassium /K Smallest number of protons/smallest nuclear charge Similar shielding / same number of shells (as other elements in period 4)	If Na or Rb lose M1 but allow access to M2 and M3 If other incorrect elements 0/3 Allow same shielding	1 1 1
03.4	Amphoteric		1
03.5	$As_2O_3 + 6Zn + 12HNO_3 \rightarrow 2AsH_3 + 6Zn(NO_3)_2 + 3H_2O$	Accept multiples	1

Question	Answers	Additional Comments/Guidelines	Mark
04.1	$[Fe(OH)_3(H_2O)_3]$ Brown $2[Fe(H_2O)_6]^{3+} + 3CO_3^{2-} \rightarrow 2[Fe(OH)_3(H_2O)_3] + 3CO_2 + 3H_2O$	 M2: Allow red-brown M3: Allow correct equations with Na_2CO_3 M3: Ignore state symbols	1 1 1
04.2	$[FeCl_4]^-$ $[Fe(H_2O)_6]^{3+} + 4Cl^- \rightarrow [FeCl_4]^- + 6H_2O$	 M2: Allow correct equations with HCl	1 1
04.3	(XS) Zn (in acid or HCl or H_2SO_4)	Allow KI/potassium iodide	1
04.4	$[Fe(OH)_2(H_2O)_4]$ green		1 1

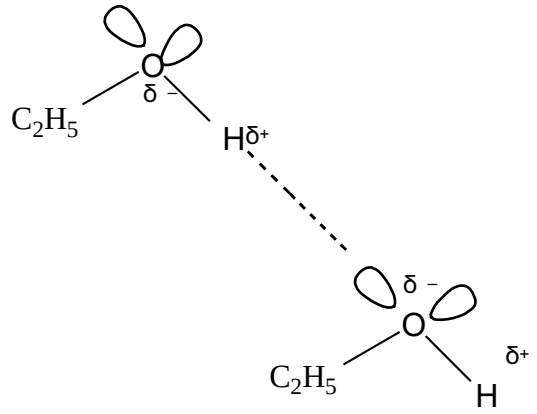
04.5	This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question. **Level 3** **5–6 marks** All stages are covered and the description of each stage is generally correct and virtually complete. Answer is communicated coherently and shows a logical progression from stage 1 to stage 2 and stage 3 Answer is illustrated using diagrams of at least 2 specific examples of pairs of cobalt or platinum complex isomers. **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. Answer is illustrated using diagrams of at least 1 specific example of a pair of cobalt or platinum complex isomers. **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. Answer is illustrated using at least 1 appropriate diagram or formula. **Level 0** **0 marks** Insufficient correct chemistry to gain a mark.	**Indicative Chemistry content** **Stage 1: shapes of complexes** 1a octahedral or 6 co-ordinate diagram 1b tetrahedral or square planar or 4 co-ordinate diagram **Stage 2: cis/ trans isomerism (or E-Z or geometric)** 2a cis/trans isomerism in either square planar and/or octahedral complexes 2b Diagrams showing cis <u>and</u> trans isomerism in a square planar complex 2c Diagrams showing cis <u>and</u> trans isomers of octahdedral complexes eg draw cis <u>and</u> trans $M(H_2O)_4(OH)_2$ or $[M(NH_3)_4(H_2O)_2]^{2+}$ **Stage 3: optical isomerism** 3a optical isomerism / non superimposable mirror images in octahedral complexes 3b occurs with a specific bidentate ligands eg.$C_2O_4^{2-}$ or $NH_2CH_2CH_2NH_2$ 3c draw both optical isomers of eg $[M(NH_2CH_2CH_2NH_2)_3]^{2+}$	6

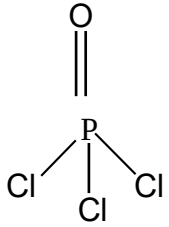
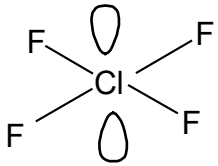
Question	Answers	Additional Comments/Guidelines	Mark
05.1	$NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$	Allow $2NaCl + H_2SO_4 \rightarrow Na_2SO_4 + 2HCl$	1
	Proton donor	Allow (Bronsted-Lowry) acid	1
05.2	$2NaBr + 2H_2SO_4 \rightarrow Na_2SO_4 + SO_2 + Br_2 + 2H_2O$ Or $2NaBr + 3H_2SO_4 \rightarrow 2NaHSO_4 + SO_2 + Br_2 + 2H_2O$ Or $2H^+ + 2Br^- + H_2SO_4 \rightarrow SO_2 + Br_2 + 2H_2O$ Or $4H^+ + 2Br^- + SO_4^{2-} \rightarrow SO_2 + Br_2 + 2H_2O$	Ignore $2NaBr + H_2SO_4 \rightarrow Na_2SO_4 + 2HBr$ Ignore $NaBr + H_2SO_4 \rightarrow NaHSO_4 + HBr$	1
	brown gas or brown fumes or orange gas or orange fumes	Do not accept yellow solid Ignore fizzing and misty fumes	1
	Oxidising agent	Allow electron acceptor Ignore acid / proton donor	1
05.3	(+)5 and -1		1
05.4	Is oxidised <u>and</u> reduced	Allow undergoes disproportionation Allows gains <u>and</u> loses electrons	1
05.5	D AgBr E Ag_2CO_3 F CO_2 $2Ag^+ + CO_3^{2-} \rightarrow Ag_2CO_3$ $AgBr + 2NH_3 \rightarrow Ag(NH_3)_2^+ + Br^-$	Ignore state symbols Or $\rightarrow Ag(NH_3)_2Br$ One mark for $Ag(NH_3)_2^+$ and 1 mark for equation If D = AgCl, then allow 2 marks for $AgCl + 2NH_3 \rightarrow Ag(NH_3)_2^+ + Cl^-$	1 1 1 1 2

Question	Answers	Additional Comments/Guidelines	Mark
06.1	M1 Amount of $S_2O_3^{2-}$ = $\frac{9.00 \times 0.0800}{1000}$ = 7.20×10^{-4} mol		1
	(From equations mol $S_2O_3^{2-}$ = mol Cu^{2+}) M2 Amount of Cu^{2+} in 25 cm^3 = 7.20×10^{-4} mol	M2 = answer to M1 (1:1 ratio)	1
	M3 Amount of Cu^{2+} in 250 cm^3 = 7.20×10^{-4} **x10** = 7.20×10^{-3} mol	M3 = M2 x 10	1
	M4 Mass of copper = 7.20×10^{-3} mol **x 63.5** = 0.457 g	M4 = M3 x 63.5	1
	M5 mass = 0.985 g	M5 converting 985mg to g	1
	M6 % Cu = 0.457 x $\frac{100}{0.985}$ = 46.4 %	M6 is for the answer to **3 sf** Allow % Cu = 457 x $\frac{100}{985}$ = 46.4 % for M5 and M6 Allow (M4 x1000)/985 x 100 for M5 and M6	1
06.2	Use more of the alloy Use a lower concentration of the thiosulfate solution/lower mass of $Na_2S_2O_3$ to make solution		1 1
06.3	Oxidizing agent	Allow electron acceptor	1
06.4	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$	Do not allow $[Ar]3d^9$	1
06.5	Full (3)d (sub)shell or $(3)d^{10}$ No (d-d) transitions possible/ cannot absorb visible/white light	M2 is dependent on M1 Ignore reflects visible/white light	1 1

06.6	M1: n = (5.00/253.8) = 0.0197 mol M2: T = 458 K and P = 100 000 Pa M3: V = $\frac{nRT}{P}$ or $\frac{0.0197 \times 8.31 \times 458}{100\,000}$ or 7.50×10^{-4} (m^3) M4: V =750 (cm^3)	Allow 254 If 126.9 or 127 used lose M1 only M3 If rearrangement incorrect can only score M1 and M2 M4: Allow M3 x 10^6 M4: Allow 749	1 1 1 1

Question	Answers	Additional Comments/Guidelines	Mark
07.1	Moles SO_2 eqbm (=6.08/64.1 = 0.0949) so moles O_2 eqbm = 0.0474 Mass of oxygen (= 0.0474 x 32(.0)) = 1.52 g	Allow 0.0475 Allow M1 x 32	1 1
07.2	M1: Mole fraction SO_3 = 0.15 Mole fraction SO_2 = 0.57 Mole fraction O_2 = 0.28 M2: $K_p = \frac{(pSO_2)^2 \times (pO_2)}{(pSO_3)^2}$ (= $\frac{(\lambda SO_2)^2 P^2 \times (\lambda O_2) P}{(\lambda SO_3)^2 P^2}$) M3: $P = \frac{K_p \times (\lambda SO_3)^2}{(\lambda SO_2)^2 \times (\lambda O_2)}$ or $\frac{K_p \times (0.15)^2}{(0.57)^2 \times (0.28)}$ M4 P = 1.91 x 10^5 (Pa) Allow range 1.88 x 10^5 to 1.94 x 10^5	Accept fractions for M1 Do not accept [ ] λ = mole fraction M3 is for rearrangement with or without numbers If incorrect rearrangement allow correct M1 and M2 only	1 1 1 1
07.3	M1 Kp is higher at higher temperature or converse M2 At higher temperature more dissociation occurs / more products are formed / equilibrium shifts to the right/forward direction	 M2: Allow converse arguments M2 dependent on M1.	1 1
07.4	(√3.94 x 10^4 Pa) = 198.5 $Pa^{1/2}$ or $Pa^{0.5}$	Allow 198 – 198.5 (answer is 198.49) If √7.62 x 10^5 = 873 then lose M1 but allow M2	1 1

Question	Answers	Additional Comments/Guidelines	Mark
08.1		**M1** two lone pairs on each O atom and δ+ and δ– on each H-O bond **M2** dotted/broken line shown between lone pair on one molecule and the correct H on another **M3** O·····H–O in straight line, dependent on M2 Ignore any partial charges on C–H or C–O bonds For straight line in **M3**, allow a deviation of up to 15° If a different molecule containing hydrogen bonding due to O–H bond drawn (e.g. methanol, water) or an incorrect attempt at the structure of ethanol, then maximum of 2 marks (i.e. only penalise if would score all three marks otherwise)	1 1 1
08.2	Hydrogen bonds (between ethanol molecules) (permanent) dipole-dipole OR van der Waals force (between methoxymethane molecules) Hydrogen bonds are stronger/est intermolecular force	 Allow vdW Allow more energy to break/overcome hydrogen bonding Allow converse arguments	1 1 1

08.3	  (distorted) Tetrahedral Square planar 90°	$POCl_3$: allow any shape showing 1 double bond between P and O and 3 P-Cl bonds ClF_4^-: allow any shape showing 4 Cl-F bonds and 2 lone pairs	1 1 1 1 1

Question	Answers	Additional Comments/Guidelines	Mark
09.1	M1: $[H^+] = [OH^-]$ M2: $[H^+]$ $(= 10^{-pH})$ = 2.138 x 10^{-7} M3: $K_w = [H^+]^2$ or $(2.138 \times 10^{-7})^2$ M4: K_w = 4.57 x 10^{-14}	M1: accept equal number/amounts of H^+ and OH^- M2: allow 2.14 x 10^{-7} M3: allow $(M2)^2$ M4: allow 4.58 x 10^{-14} M4 is dependent on (an answer)^2 in M3	1 1 1 1
09.2	View with Figure X (ie graph) as they may show working there. M1: Determines volume at half equivalence $(= \frac{19.5}{2} cm^3)$ = 9.75 (cm^3) M2: pH = 4.80 to 4.95 M3: K_a $(= 10^{-pH})$ = $10^{-4.9}$ = 1.26 x 10^{-5} Alternative method M1: pH of pure acid = 3 M2: $K_a = (10^{-3})^2 / 0.080$ M3: = 1.25 x 10^{-5}	Ignore calculations of mols of salt or acid M1: Allow reading on graph to be from 19.4 to 19.7 giving M1 = 9.7 to 9.85 M2: Reads off pH at half equivalence M3: Allow 1.12 x 10^{-5} to 1.58 x 10^{-5} M3: Allow 2sf or more Alternative M1 if calculation incorrect: Allow pH = pK_a or $[H^+] = K_a$ at <u>half equivalence</u>	1 1 1
09.3	cresolphthalein		1

09.4	M1: $K_a = \frac{[H^+][X^-]}{[HX]}$ or $[H^+] = \frac{K_a \times [HX]}{[X^-]}$ M2: amount of HX = 0.0500 mol M3: amount of HX after add^n of KOH = $0.05 - \frac{3 \times 10^{-4}}{} = 0.0497$ mol M4: amount of KX after add^n of KOH = $0.0136 + \frac{3 \times 10^{-4}}{} = 0.0139$ mol M5: $[H^+] = \left(\frac{1.41 \times 10^{-5} \times 0.0497}{0.0139}\right) = \frac{5.04(15) \times 10^{-5}}{}$ M6: pH = $-\log_{10} 5.04(15) \times 10^{-5}$ = 4.30	M1: allow $[H^+] = \frac{K_a \times [acid]}{[salt]}$ M3: = M2 – 3×10^{-4} Answer to 2 decimal places If no attempt at M3 and M4 max 2 marks If M3 or M4 attempted using 3×10^{-4} max 4 (M1, M2, M3 or M4 and M6)	1 1 1 1 1 1

09.5	ratio $\frac{[HX]}{[X^-]}$ remains (almost) constant	Allow inverse expression	1