AQA

A-LEVEL

Chemistry

7405/1 Inorganic and Physical Chemistry
Mark scheme

7405
June 2017

Version: 1.0 Final

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

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

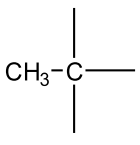
Where students are asked to draw organic structures, unless a specific type is required in the question and stated in the mark scheme, these may be given as displayed, structural or skeletal formulas or a combination of all three as long as the result is unambiguous.

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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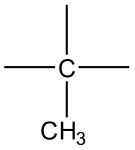

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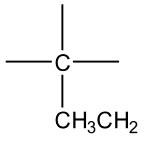

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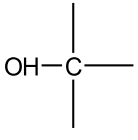

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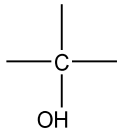

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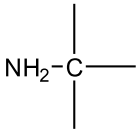

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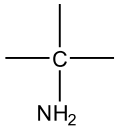

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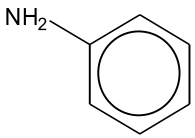

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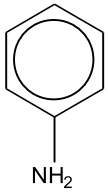

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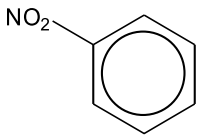

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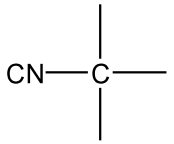

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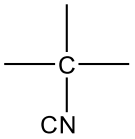

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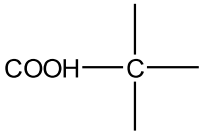

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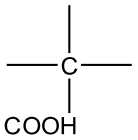

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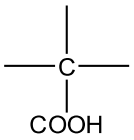

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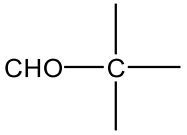

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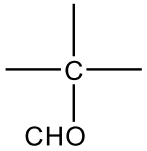

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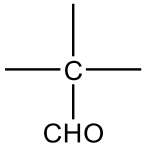

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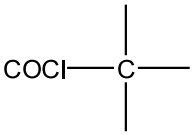

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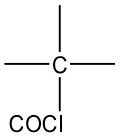


not allowed

- 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 <u>may</u> 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	ethane

- 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.

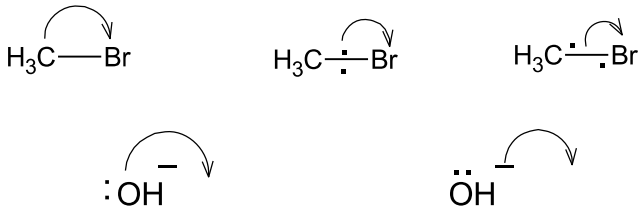
but-2-ol	should be **butan-2-ol**
2-hydroxybutane	should be **butan-2-ol**
butane-2-ol	should be **butan-2-ol**
2-butanol	should be **butan-2-ol**
ethan-1,2-diol	should be **ethane-1,2-diol**
2-methpropan-2-ol	should be **2-methylpropan-2-ol**
2-methylbutan-3-ol	should be **3-methylbutan-2-ol**
3-methylpentan	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**

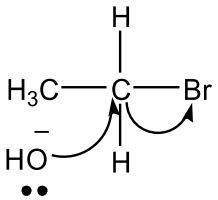
3.14 Organic reaction mechanisms

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	Mark	Additional Comments/Guidance
01.1	Enthalpy change or heat energy change when 1 mol of solid ionic compound/substance or 1 mol of ionic lattice is formed from its gaseous ions.	1 1	Allow: enthalpy change for: $M^+ (g) + X^- (g) \rightarrow MX (s)$ or $Ag^+ (g) + I^- (g) \rightarrow AgI (s)$ CE=0/2 if describing wrong process (eg ΔH of lattice dissociation or ΔH of formation/ or heat energy required) Ignore heat energy released
01.2	lattice dissociation energy= (112 + 464 + 293) = + 869 ($kJmol^{-1}$) lattice formation energy = − 869 ($kJ\ mol^{-1}$)	1 1	 (+)869 = 1 mark
01.3	AgI contains covalent character Forces/bonds (holding the lattice together) are stronger	1 1	CE=0/2 if atoms/molecules For M1, allow the following: not completely ionic / ions not spherical / ions distorted/ some covalent bonding Ignore covalent bonds stronger (than ionic bonds) Ignore electronegativity Ignore references to energy
01.4	$AgNO_3$ yellow ppt or Cl_2 or Br_2 brown solution/black ppt	1 1	Ignore ammonia/acidified/nitric acid/sulphuric acid M2 dependent on correct M1 but mark on from Ag^+ or Tollens
Total		**8**	

Question	Answers	Mark	Additional Comments/Guidance
02.1	$[H^+] = (10^{-3.87} =) 1.3489 \times 10^{-4}$	1	Allow 1.35×10^{-4}. If M1 wrong can only score M2.
	$[CH_3COOH] = \frac{[H^+][CH_3COO^-]}{[Ka]} = (\frac{[1.3489 \times 10^{-4}][0.136]}{[1.74 \times 10^{-5}]} = 1.05436)$	1	Mark is for correctly rearranged equation.
	1.05 – 1.06 (mol dm^{-3})	1	3 sf or more

02.2	**If 0.007 moles in 500 cm^3 seen follow Mark Scheme 1** **Mark Scheme 1** moles ethanoic acid = 0.130 moles sodium ethanoate = 0.0605 mol CH_3COOH after addition = (0.130 - 0.007) = 0.123 mol CH_3COO^- after addition = (0.0605+0.007) = 0.0675 $[H^+] = \left(\frac{[Ka][CH_3COOH]}{[CH_3COO^-]}\right) = \frac{[1.74 \times 10^{-5}][0.123]}{[0.0675]}$ (= 3.171 x 10 $^{-5}$) pH = <u>4.50</u> (must be 2dp) **If 0.014 moles in 1 dm^3 follow Mark Scheme 2** **Mark scheme 2** moles CH_3COOH after addition = (0.260 - 0.014) = 0.246 (This scores 2 marks) moles CH_3COO^- after addition = (0.121+0.014) = 0.135 (This scores 2 marks) $[H^+] = \left(\frac{[Ka][CH_3COOH]}{[CH_3COO^-]}\right) = \frac{[1.74 \times 10^{-5}][0.246]}{[0.135]}$ pH = <u>4.50</u> (must be 2dp)	1 1 1 1 1 1	Method 1 For M3 allow M1 – 0.007 For M4 allow M2 + 0.007 Method 1 and 2 M5 = expression with their numbers M6 = answer to 2 dp pH = 4.50 scores 6 marks If √ used in K_a expression, stop at M4 If divide by 2 after M5, lose M6 Allow solutions which use Henderson-Hasselbach Equation

Total		**9**	

Question	Answers	Mark	Additional Comments/Guidance
03.1	Ans = C	1	
03.2	$[H^+] = \sqrt{K_w} = \sqrt{2.93 \times 10^{-15}}$ (= 5.41×10^{-8}) pH = (− log (5.41×10^{-8}) = <u>7.27</u>	1 1	 Must be 2dp 7.27 scores 2 marks
03.3	$[H^+] = [OH^-]$	1	allow description in words equal moles/quantities/numbers/ratio of H^+ and OH^-
03 4	$[OH^-] = 0.0131$ <u>x 2</u> = 0.0262 $[H^+] = (K_w / [OH^-]) = 2.93 \times 10^{-15} / 0.0262$ (= 1.118×10^{-13}) pH = (− log (1.118×10^{-13}) = 12.9514 = 12.95 **Or** $[OH^-] = 0.0131 \times 2 = 0.0262$ pOH = (−log 0.0262) = 1.5817 pH =(−log K_w− pOH = −log 2.93×10^{-15}−1.58 =14.53−1.58) = 12.95	1 1 1	pH = 12.95 scores 3 marks pH = 12.42 scores 2 marks ($K_w = 1 \times 10^{-14}$) pH = 12.65 scores 1 mark (not multiplied by 2) pH = 12.35 scores 1 mark (divided by 2) pH = 12.12 scores 0 marks (no x2 and wrong K_w) allow to 2dp or more

03.5	smaller / lower pH / less alkaline / more acidic	1	If not smaller CE = 0/2 Allow pH number between 8 and 12
	(magnesium hydroxide) is less soluble / sparingly soluble/ solubility of hydroxide increases down group II	1	M2 dependent on M1 but if blank mark on Ignore concentration and dissociation Ignore incorrect formula Do not allow $Mg(OH)_2$ is insoluble

Total		**9**	

Question	Answers	Mark	Additional Comments/Guidance
04.1	$\frac{(46 \times 9.1) + (47 \times 7.8) + (48 \times 74.6) + (49 \times 8.5)}{100} = \frac{4782.5}{100}$ = 47.8	1 1	Correct answer scores 2 marks. Allow alternative methods. Allow 1dp or more. Ignore units
04.2	$Ti(g) \rightarrow Ti^{+}(g) + e^{-}$ or $Ti(g) + e^{-} \rightarrow Ti^{+}(g) + 2e^{-}$ or $Ti(g) - e^{-} \rightarrow Ti^{+}(g)$ 46	1 1	State symbols essential Allow electrons without $^{-}$ charge shown.
04.3	$8.1(37) \times 10^{-26}$	1	

Question	Answers	Mark	Additional Comments/Guidance
04.4	M1 is for re-arranging the equation $d = t\sqrt{\frac{2E}{m}}$ or $d = \frac{t}{\sqrt{\frac{m}{2E}}}$ or $d^2 = t^2 \times \frac{2E}{m}$ $d = t_{47}\sqrt{\frac{2E}{47 \times 10^{-3}/L}} = t_{49}\sqrt{\frac{2E}{49 \times 10^{-3}/L}}$ **Or** d = 1.5(47) This scores 2 marks = 9.6(14) x 10^{-7}	1 1 1	Allow t α square root of m Allow this expression for M2 $\frac{t_{47}}{\sqrt{47}} = \frac{t_{49}}{\sqrt{49}}$ Correct answer scores 3 marks.
Total		**8**	

Question	Answers	Mark	Additional Comments/Guidance
05.1	$\Delta S = \Sigma S$ products – ΣS reactants or 253 + (2 x 198) – (2 x 223 + 2 x 5.7 + 50.2) (= 649 – 507.6)	1	This expression could also score M1
	ΔS = 141(.4) (J $K^{-1}mol^{-1}$)	1	This scores M1 and M2 Allow ecf for M3, M4 and M5 from incorrect M2
	$\Delta G = \Delta H - T\Delta S$	1	
	ΔG = -60 - (1262 x 141(.4) x 10^{-3})	1	This expression also scores M3. For M4, allow ΔG = -60 - (1262 x their M2 x 10^{-3})
	= –238 (kJ mol^{-1}) to 3 sig figs	1	If calculated in joules M4: Allow ΔG = -60x10^3 - (1262 x 141(.4)) M5: Allow -238 000 J mol^{-1} providing units shown
	feasible since ΔG is negative/less than zero	1	Allow consequential M6 from their ΔG
Total		**6**	

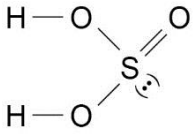
Question	Answers	Mark	Additional Comments/Guidance
06.1	$P_4 + 5\ O_2 \rightarrow P_4O_{10}$	1	allow $4\ P + 5\ O_2 \rightarrow P_4O_{10}$ allow multiples ignore state symbols
06.2	React with water / add water / solution (of substances in question) Add litmus paper / universal indicator / measure pH (with pH meter) <u>M3 is dependent on M2</u> Litmus: blue with sodium oxide (solution) **and** red with phosphorus oxide (solution)OR If blue litmus added phosphorus oxide solution goes red OR If red litmus added sodium (hydr)oxide goes blue Universal Indicator: blue/ purple with sodium oxide (solution) **and** red with phosphorus oxide (solution) pH meter or Universal Indicator: sodium (hydr)oxide (solution) has a higher pH (than phosphorus oxide (solution)) or vv sodium (hydr)oxide pH (12 to 14) **and** phosphorus oxide (solution) pH (-1 to 2)	1 1 1	If no M1 then CE = 0/3 Allow other reagents in solution, eg sodium carbonate solution, that give a positive result Allow other indicators with appropriate colour changes For pH meter or Universal Indicator: allow sodium (hydr)oxide (solution) has a higher pH and phosphorus oxide (solution) has lower pH.

06.3	For silicon dioxide - giant covalent (molecule)/ macromolecular For sulfur trioxide - molecular / (simple) molecule	1 1	Do not allow simple covalent

06.4	Covalent bonds (between atoms) in SiO_2 Van der Waals <u>between</u> <u>molecules</u> / intermolecular forces in SO_3 Covalent bonds are stronger than van der Waals forces (Covalent bonds) take more energy to be <u>overcome</u>/<u>broken</u> or (Van der Waals) take less energy to be <u>overcome/broken</u>	1 1 1 1	If covalent bonds between molecules of SiO_2 lose M1 only If hydrogen bonds in SO_3 lose M2 only If metallic or ionic max score = 1 (either M1 or M2) If IMF in SiO_2 then max 1 (M2 only) Allow dipole-dipole forces between molecules For M3 and M4 comparison is required/implied

06.5	$SO_3 + 2KOH \rightarrow K_2SO_4 + H_2O$ $SO_3 + KOH \rightarrow KHSO_4$ $SO_3 + 2OH^- \rightarrow SO_4^{2-} + H_2O$ $SO_3 + OH^- \rightarrow HSO_4^-$	1	Allow multiples Ignore state symbols

06.6	$3\ MgO + 2\ H_3PO_4 \rightarrow Mg_3(PO_4)_2 + 3\ H_2O$	1	Allow multiples Ignore state symbols

Question	Answers	Mark	Additional Comments/Guidance
06.7		1	Ignore lone pairs
Total		**13**	

Question	Answers	Mark	Additional Comments/Guidance
07.1	Covalent	1	Do not allow dative covalent or coordinate (covalent)
07.2	$Cl^{(-)}$ not donating lone pair (to $Cu^{(2+)}$) $Cl^{(-)}$ does not form a coordinate/dative bond (to $Cu^{(2+)}$)	1	Allow without charges but penalise incorrect charges Cl^-/it is bonded ionically (to Cu^{2+})
07.3	$[Cu(H_2O)_6]^{2+} + 4NH_3 \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+} + 4H_2O$ Deep blue / Royal blue / Dark blue (solution)	1 1	Allow combination of: $[Cu(H_2O)_6]^{2+} + 2NH_3 \rightarrow [Cu(H_2O)_4(OH)_2] + 2NH_4^+$ $[Cu(H_2O)_4(OH)_2] + 4NH_3 \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+} + 2H_2O + 2OH^-$ Do not penalise missing square brackets Ignore initial colour of Cu^{2+} (aq)
07.4	$CuCO_3$ or copper carbonate	1	Penalise incorrect oxidation state Allow correct formula for basic copper carbonate
07.5	HCl/ hydrochloric acid $[Cu(H_2O)_6]^{2+} + 4Cl^- \rightarrow [CuCl_4]^{2-} + 6H_2O$ $[Cu(H_2O)_6]^{2+} + 4HCl \rightarrow [CuCl_4]^{2-} + 6H_2O + 4H^+$	1 1	Ignore concentration Allow soluble chloride salt Also allow any reagent which leads to a change in colour of solution due to a change in ligands (eg $NH_2CH_2CH_2NH_2$) or change in oxidation state (eg SO_2) and associated correct equations. Mark independently

07.6	(3)d^{10} or has full (3)d (sub) shell/orbital It is colourless/cannot absorb (frequencies of) visible light	1 1	Penalise incorrect principal quantum number Ignore clear

Total		**9**	

Question	Answers	Mark	Additional Comments/Guidance
08.1	$BaCl_2$ / $Ba(OH)_2$ / $Ba(NO_3)_2$ / BaX_2 or names	1	Ignore acidification but CE = 0/3 if H_2SO_4 If reagent incorrect or blank then CE =0/3 If Ba^{2+} or wrong formula, lose M1 and mark on
	colourless solution / no (visible) change (nvc) / no ppt / no (visible) reaction	1	Ignore nothing happens and no observation
	white precipitate / white solid	1	
08.2	NaOH / sodium hydroxide / other Group 1 hydroxides	1	If reagent incorrect or blank then CE =0/3 If reagent incomplete, lose M1 and mark on
	white precipitate / white solid	1	
	(white) ppt which dissolves in excess (NaOH)	1	If reagent is excess NaOH, allow colourless solution for M3
	Alternative Method Name or formula of Group 1 carbonate	1	
	white precipitate / white solid	1	
	(white) precipitate and effervescence	1	
Total		**6**	

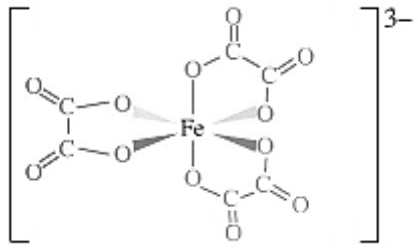
Question	Answers		Mark	Additional Comments/Guidance
09.1	This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.		6	**Indicative Chemistry content** **Stage 1: Deductions from graph** 1a Yield increases as temperature increases (or converse) 1b After a certain temperature yield no longer increases 1c Yield decreases as pressure increases (or converse) **Stage 2: Optimum temperature and explanation** 2a High temperature results in high energy costs/expensive 2b (After a certain temperature) yield no longer increases therefore there is no gain in using a higher temperature 2c Optimum temperature is between 780-880^{o}C **Stage 3: Optimum pressure and explanation** 3a Low pressure may be too slow 3b So compromise pressure required 3c Optimum pressure is 1000-2000kPa or moderate pressure used
	Level 3 5–6 marks	All stages are covered and the explanation of each stage is generally correct and virtually complete. To access Level 3, statement 3a must be considered. Answer is communicated coherently and shows a logical progression from stage 1 (including 1b) to stage 2 and stage 3		
	Level 2 3–4 marks	All stages are covered but the explanation 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 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 includes isolated statements but these are presented in a logical order, with sensible reasoning.		

	Level 0 0 marks	Insufficient correct chemistry to gain a mark.		

Question	Answers	Mark	Additional Comments/Guidance
09.2	Moles of carbon monoxide 17.9 Moles of hydrogen 19.9	1 1	Allow 17.94 Allow 19.88
09.3	$K_p = \frac{pp(CH^3OH)}{pp(CO)\times pp(H_2)2}$ ignore brackets Total moles of gas = (2.76 + 4.51 + 0.36) = 7.63 $pp(CO) = \frac{2.76}{7.63}$ x 630 (kPa) (= 228 (kPa)) $pp(H_2) = \frac{4.51}{7.63}$ x 630 (kPa) (= 372 (kPa)) $pp(CH_3OH) = \frac{0.36}{7.63}$ x 630 (kPa) (= 29.7 (kPa)) $K_p = \frac{29.7}{228x(372)2}$ = 9.4(1) x 10^{-7} or 9.4(1) x 10^{-13} if *pp* in Pa can also score M1 from this expression $\underline{kPa^{-2}}$ or $\underline{Pa^{-2}}$ (if converted to 630 000)	1 1 2 1 1	If K_p expression incorrect can only score M2 & M3 & M4 If CE in M2 allow ecf for M3, M4 and M6 If no total moles calculated then can only score M1 and M6 All 3 pp of CO, H_2 and CH_3OH = 2 marks 2 pp correct = 1 mark Allow 9.39 to 9.50 x 10^{-7} (kPa^{-2}) If no marks awarded allow M6 only for $\underline{kPa^{-2}}$ or $\underline{Pa^{-2}}$
Total		**14**	

Question	Answers	Mark	Additional Comments/Guidance
10.1	(+) 5 (+) 2	1 1	Allow Roman numerals
10.2	Cl^- / chloride (ions)	1	Allow $2Cl^-$ Do not allow chlorine / Cl / Cl_2 Ignore (aq)
10.4	nitric acid / HNO_3	1	If not nitric acid then CE = 0 If NO_3^- ions identified, lose M1 and mark on
	the $E^\ominus$ $\underline{NO_3^=}$ (/NO) > $E^\ominus$ $\underline{Cu^{2+}}$(/Cu) or in words	1	Allow 0.96V > 0.34V Allow $\underline{NO_3^=}$ is a better oxidising agent than $\underline{Cu^{2+}}$ Allow $\underline{NO_3^=}$ has a more positive $E^\ominus$ than $\underline{Cu^{2+}}$
	$3Cu + 8H^+ + 2NO_3^- \rightarrow 3Cu^{2+} + 2NO + 4H_2O$	1	Allow $3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$
	EMF for the reaction is $\underline{0.62}$(V)	1	
Total		**9**	

Question	Answers	Mark	Additional Comments/Guidance
11.1	Moles MnO_4^- $\frac{26.50 \times 0.02}{1000} = 5.30 \times 10^{-4}$	1	The first CE is penalised by 2 marks; further errors are penalised by one mark each
	Moles in 25cm^3 sample / pipette $C_2O_4^{2-}$ (from acid and salt) = 5.30×10^{-4} **x 5/2** = (1.325×10^{-3})	1	M2 = M1 x 5/2
	Moles NaOH = $\frac{10.45 \times 0.1}{1000} (= 1.045 \times 10^{-3})$	1	
	So moles $C_2O_4^{2-}$ from acid in 25cm^3 sample / pipette = 1.045×10^{-3} **÷ 2** = 5.225×10^{-4}	1	M4 = M3 ÷ 2
	Hence moles $C_2O_4^{2-}$ in sodium ethanedioate in 25 cm^3 = $1.325 \times 10^{-3} - 5.225 \times 10^{-4}$ $(= 8.025 \times 10^{-4})$	1	M5 = M2 – M4 (do not allow if negative and do not allow = M4-M2) **If no subtraction, max = 5 (M1, M2, M3, M4 and M6)** **If incorrect subtraction, max = 6 (M1, M2, M3, M4, M6 and M7)**
	So moles $C_2O_4^{2-}$ in sodium ethanedioate in original sample = 8.025×10^{-4} **x 10** $(= 8.025 \times 10^{-3})$	1	M6 = M5 x 10 (M6 can be scored by multiplying M2 and M4 by 10 before subtraction (giving $1.325 \times 10^{-2} - 5.225 \times 10^{-3} = 8.025 \times 10^{-3}$)
	Mass $Na_2C_2O_4 = 8.025 \times 10^{-3}$ **x 134(.0)** = $1.075(35)$ g	1	M7 = M6 x 134
	So % sodium ethanedioate in original sample $\frac{1.075(35)}{1.90} \times 100$ = 56.6 % to 3 sig fig	1	M8 = (M7/1.90)x100 Allow 56.5 – 56.8%

Question	Answers	Mark	Additional Comments/Guidance
11.2	$[Fe(H_2O)_6]^{3+} + 3C_2O_4^{2-} \rightarrow [Fe(C_2O_4)_3]^{3-} + 6H_2O$ There are <u>6</u> Fe –O bonds broken and then made / <u>same</u> number and type of bond being broken and made.	1 1	
11.3	 90^o or 180^o <u>optical</u>	1 1 1	Ignore all charges even if wrong Ignore absence of square brackets Candidates do not need to show 3D shape
11.4	The ethanedioic acid is only present in small quantities/low concentration in these foods.	1	
Total		**14**	