



GCE

Chemistry B

H433/02: Scientific literacy in chemistry

A Level

Mark Scheme for June 2023

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It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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PREPARATION FOR MARKING

RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Online Training*; *OCR Essential Guide to Marking*.
2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are available in RM Assessor.
3. Log-in to RM Assessor and mark the **required number** of practice responses (“scripts”) and the **required number** of standardisation responses.

MARKING

1. Mark strictly to the mark scheme.
2. Marks awarded must relate directly to the marking criteria.
3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% (traditional 50% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.
4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the RM Assessor messaging system.

5. **Crossed Out Responses**

Where a candidate has crossed out a response and provided a clear alternative then the crossed out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed out response where legible.

Rubric Error Responses – Optional Questions

Where candidates have a choice of question across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. Enter a mark for each question answered into RM assessor, which will select the highest mark from those awarded. *(The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)*

Multiple Choice Question Responses

When a multiple choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).

When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses

When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only **one mark per response**)

Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. *(The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)*

Short Answer Questions (requiring a more developed response, worth **two or more marks**)

If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space.)

Longer Answer Questions (requiring a developed response)

Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add 'SEEN' to confirm that the work has been seen.

7. There is a NR (No Response) option. Award NR (No Response)

- if there is nothing written at all in the answer space

- OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')

- OR if there is a mark (e.g. a dash, a question mark) which isn't an attempt at the question.

Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The RM Assessor **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

If you have any questions or comments for your Team Leader, use the phone, the RM Assessor messaging system, or email.

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by levels of response:

Read through the whole answer from start to finish, using the Level descriptors to help you decide whether it is a strong or weak answer. The indicative scientific content in the Guidance column indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance. Using a 'best-fit' approach based on the skills and science content evidenced within the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer.

Once the level is located, award the higher or lower mark:

The higher mark should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met.

The lower mark should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing.

In summary:

The skills and science content determines the level.

The communication statement determines the mark within a level.

Level of response questions on this paper are **2e** and **4 d(ii)**

The only annotation on a level of response question should be the indication of the level.
Please do not use ticks or highlight areas.

The appropriate level annotation should be used e.g. If a candidate has 6 marks, they would have the annotation **L3** on their script.

If a candidate has achieved 5 marks then they have reached Level 3 but without the communication mark. They should have the following annotations on their script: **L3** **^**

The same principle should be applied to Level 2 and Level 1.

No marks (0) should have a cross.

Any response deemed NR should also be annotated with SEEN

Please place the annotations in the left-hand margin of the main answer space.

11. On additional pages, please annotate using 'SEEN'

Annotations available in RM Assessor

Annotation	Meaning
	Correct response
	Incorrect response
	Omission mark
	Benefit of doubt given
	Contradiction
	Rounding error
	Error in number of significant figures
	Error carried forward
	Level 1
	Level 2
	Level 3
	Benefit of doubt not given
	Noted but no credit given
	Ignore

12. Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
✓	Separates marking points
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
()	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

13. Subject-specific Marking Instructions

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

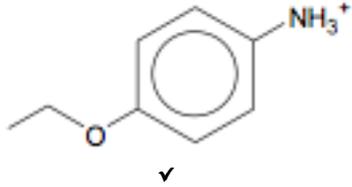
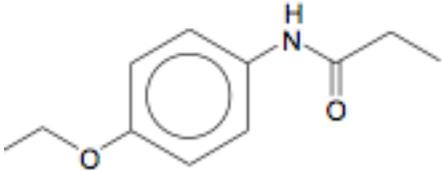
- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

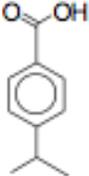
You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

Question			Answer	Mark	AO element	Guidance
1	a	i	$2\text{Br}^- + \text{Cl}_2 \rightarrow \text{Br}_2 + 2\text{Cl}^-$ ✓ chlorine gains electrons from bromide ions (AW) / chlorine displaces bromine ✓	2	1.1 2.3	IGNORE state symbols
1	a	ii	Bromine/ Br_2 ✓ Oxidation state of Br changes from 0 to -1 OR oxidation state of S changes from +4 to +6 ✓	2	2.1 x 2	DO NOT ALLOW Br on its own ALLOW sign indicated after the number Oxidation states may be indicated above equation Incorrect Oxid'n state CON's a correct oxid'n state
1	a	iii	chlorine green gas AND bromine red/orange/brown liquid ✓ iodine grey/black solid ✓	2	1.1 x 2	ALLOW green/yellow for chlorine but not yellow on its own/ no other colours ALLOW any combination of the colours given for bromine and iodine but no others
1	b		Any two from: ✓✓ volatile (AW) corrosive toxic/poisonous	2	2.1 x 2	IGNORE vague responses such as harmful, irritates skin etc. ALLOW causes (chemical) burns
1	c	i	$\text{Ag}^+(\text{aq}) + \text{Br}^-(\text{aq}) \rightarrow \text{AgBr}(\text{s})$ equation ✓; state symbols ✓	2	1.2 x 2	ss dependent upon attempt at balanced eq'n eg $\text{Ag}^{2+}(\text{aq}) + 2\text{Br}^-(\text{aq}) \rightarrow \text{AgBr}_2(\text{s})$
1	c	ii	(White ppt is) AgCl / silver chloride ✓ Much more Cl^- than Br^- (AW) ✓	2	3.2 x 2	ALLOW silver ions/ Ag^+ react with chloride ions/ Cl^-
1	d		FIRST CHECK ANSWER ON ANSWER LINE If concentration = 0.187 (mol dm⁻³) award 2 marks (amount $\text{S}_2\text{O}_3^{2-}$ =) $24.65 \times 0.380/1000 = 9.37 \times 10^{-3}$ mol ✓ conc $\text{Br}_2 = 9.37 \times 10^{-3} \times 0.5 \times 1000/25.0 = 0.187$ mol dm ⁻³ ✓	2	2.4 x 2	ALLOW answers that round to 0.19 ALLOW ecf from MP1
1	e		amount $\text{Br}_2 = 160 \times 20/159.8 \times 1000 = 0.020$ mol ✓ amount hydrocarbon = $0.8/80 = 0.010$ mol ✓ so 2 double bonds per molecule (of hydrocarbon) ✓ structure – a cyclohexadiene (name or formula) ✓	4	3.1 3.1 3.2 3.2	ALLOW MP3 from structural formula even if MP4 not awarded
				18		

Question		Answer	Mark	AO element	Guidance
2	a	ether ✓	1	1.1	
2	b	i	1	1.1	
2	b	ii	2	1.2 x 2	ALLOW 0.10/0.1 ALLOW 0.14
2	b	iii	3	3.3 3.3 3.4	ALLOW ecf mol compound A from b(ii) ALLOW actual yield > theoretical yield/ contains impurities/ sample still wet ALLOW dry it
2	c	 + CH ₃ COOH ✓	2	2.5 x 2	ALLOW any unambiguous formula for ethanoic acid.
2	d	 amide formed ✓ structure fully correct ✓	2	2.5 x 2	

2	e	<p>Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.</p> <p>Level 3 (5–6 marks) Correct structure with some evidence from each spectrum.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3–4 marks) Correct structure with little evidence OR 'Partially correct' structure with evidence from each spectrum OR Some evidence from each spectrum with incorrect or no structure given</p> <p><i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i></p> <p>Level 1 (1–2 marks) Correct structure with no evidence OR 'Partially correct' structure with evidence from either spectrum. OR Evidence from each spectrum with incorrect or no structure given.</p> <p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks <i>No response or no response worthy of credit.</i></p>	6	<p>4 x AO3.1</p> <p>2 x AO3.2</p>	<p>Indicative scientific points include:</p> <p>AO3.1 Analyse</p> <p>¹H NMR</p> <ul style="list-style-type: none"> • 5 peaks evident therefore this indicates 5 different environments • δ in region of 1.2 ppm indicates HC-C • doublet, so C is next to CH • δ in region of 3.0 ppm is a multiplet/heptet so C is next to Cs with many/six Hs • δ in region of 7 – 8 ppm indicates aromatic Hs • δ in region of 13 ppm indicates H of COOH group <p>¹³C NMR</p> <ul style="list-style-type: none"> • 7 peaks evident therefore this indicates 7 different environments • three identical pairs (since C₁₀) • at least 2 C-C at δ in region of 0-50ppm • 4 aromatic Cs δ in region of 120 – 140ppm • two must be identical pairs • C=O at δ in region of 170ppm <p>AO 3.2 Interpret and Evaluate</p> <p>Correct structure is 4-propan-2-ylbenzoic acid (name not required). Accept any unambiguous representation</p>  <p>'partially correct' structures must include an aromatic ring, a COOH group and match the molecular formula to score at Level 1 & 2</p>
			17		

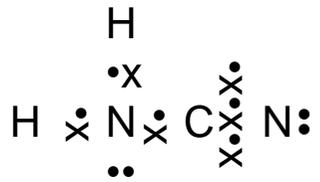
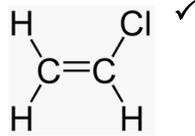
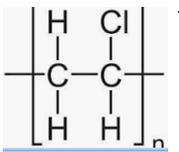
Question			Answer	Mark	AO element	Guidance
3	a	i	Reaction is slower (since molecules less concentrated/further apart)/ORA ✓ Lower rate of collision /ORA ✓ Greater yield / equilibrium moves to the RHS /ORA ✓ Fewer molecules on LHS/more molecules on RHS ✓	4	4 x 3.1	ALLOW rate decreases at low pressure ALLOW 'frequency' for 'rate' ALLOW 'moves to the right'
3	a	ii	FIRST CHECK ANSWER ON ANSWER LINE If $K_c = 4.75/4.76 \times 10^{-7}$ award 3 marks (Mark units separately) [CO ₂] = 0.0176, [CH ₄] = 0.982 ✓, [H ₂ O] = 0.965 ✓ substitute into $K_c = 4.75 \times 10^{-7}$ ✓ units: mol ² dm ⁻⁶ ✓	4	4 x 2.8	ALLOW answers rounding to 4.75(6) x 10 ⁻⁷ ALLOW ecf from wrong concentrations for 3 rd mpt
3	a	iii	The same AND K_c does not vary with pressure/only varies with temperature ✓	1	1.2	
3	a	iv	$(4 \times 130) + 214 - (2 \times 189) - 186 (= 170)$ ✓	1	2.6	ALLOW $(520 + 214) - (378 + 186)$ Working essential
3	a	v	$\Delta_{\text{tot}}S = \Delta_{\text{sys}}S - \Delta H/T$ (implied or stated) ✓ $\Delta_{\text{tot}}S = +170 - 165000/1023 (= +8.7 / 9)$ ✓ Feasible, since positive ✓	3	2.6 2.6 3.2	ALLOW correct use of $\Delta G = \Delta H - T\Delta S$ $\Delta G = 165 - (170/1000 \times 1023K) = -8.91$ Feasible since ΔG is negative. ALLOW ecf from ($\Delta_{\text{tot}}S$ as) a negative value, therefore reaction is not feasible
3	a	vi	1. increased vibrational energy (of bonds) / bonds vibrate more ✓ increased KE/molecules move faster ✓ 2. re-emit IR – towards Earth ✓	3	3 x 1.2	ALLOW 1 and 2 in either order. DO NOT ALLOW reflects IR
3	b	i	$2\text{H}_2\text{O} \rightarrow 4\text{e}^- + 4\text{H}^+ + \text{O}_2$ Formation of O ₂ ✓ Equation correct ✓	2	2 x 2.2	
3	b	ii	FIRST CHECK ANSWER ON ANSWER LINE If time = 5.36 (hr) then award 3 marks. 20.0 g = 10 mol H ₂ ✓ $10 \times 2 \times 96500/100 = 19300 \text{ s}$ ✓ $/3600 = 5.36 \text{ hr}$ ✓	3	3 x 2.2	ALLOW 2 or more sf ALLOW ecf ALLOW 536/10.72/2.68 hrs for 2 marks
3	b	iii	(True,) fossil fuels are not sustainable/renewable/they produce CO ₂ /are not carbon neutral AW ✓ other named green method of producing electricity (eg wind, solar) can be used AW ✓	2	2 x 3.2	IGNORE comments relating to 'atom economy' ALLOW nuclear
				23		

Question			Answer	Mark	AO element	Guidance
4	a		reduction	1	1.1	
4	b		<p>FIRST CHECK ANSWER ON ANSWER LINE If mass = 3×10^{-3} or 0.003 (g) then award 2 marks.</p> <p>mass acetone per 100 cm³ = $6 \times 10^{-4} \times 58/10 = 3(.48) \times 10^{-3}$ g ✓ 1 sf ✓</p>	2	1.2 3.1	Mark independently
4	c	i	gas (liquid) chromatography/GLC ✓	1	1.2	
4	c	ii	<p>15 – CH₃⁺ ✓</p> <p>43 – CH₃CO⁺ ✓</p> <p>59 – M⁺ with one ¹³C (AW) ✓</p>	3	3 x 2.1	ALLOW second (and third) absence of plus charge.
4	d	i	nucleophilic substitution ✓	1	1.1	IGNORE 'hydrolysis'

Question			Answer	Mark	AO element	Guidance
4	d	ii	<p>Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.</p> <p>Level 3 (5–6 marks) Explains reactivity in terms of bond enthalpy and bond polarity, and designs a suitable practical procedure to test their theory including a relevant improvement to the procedure.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3–4 marks) Explains reactivity in terms of bond strength OR bond polarity AND designs a suitable practical procedure to test their theory. OR Explains reactivity in terms of bond enthalpy and bond polarity but fails to develop a suitable practical procedure OR Designs a fully detailed practical procedure including one improvement to the basic procedure, but fails to discuss bond enthalpy and bond polarity</p> <p><i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i></p> <p>Level 1 (1–2 marks) Attempts to explain reactivity making some points from AO3.2 OR Attempts to design a practical procedure using some points from AO3.3 or AO3.4</p> <p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks <i>No response or no response worthy of credit.</i></p>	6	<p>3.2 x 3</p> <p>3.3 x 2</p> <p>3.4 x 1</p>	<p>Indicative scientific points include:</p> <p>AO3.2 Explanation Bond enthalpy</p> <ul style="list-style-type: none"> • C–I/C–Br bond is weaker than C–Cl • so iodo/bromo predicted faster (AW) • C–I broken more easily <p>Bond Polarity</p> <ul style="list-style-type: none"> • I/Br less electronegative than Cl • C–I/C–Br less polar than C–Cl • C–Cl broken more easily • attack by nucleophile/ OH⁻ easier/faster • so chloro predicted faster (AW) <p>AO3.3 Designs practical procedure</p> <ul style="list-style-type: none"> • use of AgNO₃ • ppt of silver halide formed (AW) • use of at least two haloalkanes <p>AO3.4 Relevant improvements to procedure</p> <ul style="list-style-type: none"> • equal volumes • equal concentration of AgNO₃ • ethanol as solvent • time until appearance of ppt

Question		Answer	Mark	AO element	Guidance
4	e	secondary ✓ C with OH is attached to two other C (atoms)/2 alkyl groups ✓	2	2 x 1.2	ALLOW OH group attached to carbon atom with one hydrogen attached ALLOW can be oxidised to a ketone
4	f	EITHER Warm/heat with acidified/H ⁺ (sodium/potassium) dichromate/formula ✓ green colour ✓ OR Warm with Tollens' reagent ✓ Silver mirror seen ✓ OR Warm/heat with Fehling's solution ✓ Red/orange ppt seen ✓	2	2 x 1.2	Observations dependent upon correct reagent used IGNORE initial colours of reagents ALLOW ammoniacal silver nitrate
4	g	i			
			3	3 x 1.1	Curly arrows should start as shown (extended if necessary) (or on minus charges of C and O) and end as shown (extended if necessary) (or else pointing to a bond formed) ALLOW negative charge on N of CN but then arrow must start from a lone pair on the C to score MP1
4	g	ii			
		cyan(o)hydrin ✓	1	1.2	ALLOW (2-)hydroxynitrile
			22		

Question		Answer	Mark	AO	Guidance	
5	a	White circle labelled Ca ²⁺ /cation ✓ <u>two joined</u> black circles labelled C ₂ ²⁻ /anion ✓	2	2 x 2.1	Carbide label can be to solid line joining 2 black dots/ a pair of circled black dots	
5	b	Benefits: production of acetylene/PVC ✓ and cyanamide/fertiliser ✓ Disadvantages: <i>two from:</i> ✓ ✓ production of CO ₂ ; production of CO; production of PH ₃ use of large amounts of energy/high temperature (AW)	4	4 x 3.1	ALLOW CO used as a fuel IGNORE carbide lamps	
5	c	FIRST CHECK ANSWER ON ANSWER LINE If percentage = 80(%) then award 3 marks. amount acetylene = 0.33/0.024 = 13.75 mol ✓ mass carbide = 13.75 x 64 = 880 g ✓ % = 880 x 100/ 1.1 x 1000 = 80% ✓	3	3 x 2.6	ALLOW answers rounding to 80. ALLOW use of gas equation ALLOW ecf Alternative method: Amt carbide if 100% pure = 1100/64 = 17.19 mol ✓ Amt ethyne = 0.33 x 10 ³ /24 = 13.75 ✓ % = 13.75 x 100/17.19 = 80% ✓	
	d	i	$C_2H_2 + 1.5 O_2 \rightarrow CO_2 + H_2O + C$ ✓	1	2.8	ALLOW other balanced equations producing C, H ₂ O and CO ₂
	d	ii	$Ca_3P_2 + 6H_2O \rightarrow 2PH_3 + 3Ca(OH)_2$ formula of Ca ₃ P ₂ ✓ Equation correct ✓	2	2 x 2.8	IGNORE ss ALLOW ionic equation showing OH ⁻ ions(1) and balanced(1)

5	e	i	 <p>triple bond ✓ rest of structure ✓</p>	2	2 x 2.5	
5	e	ii	<p>180(°) ✓ two areas of electron density (around C) ✓ repel and get as far apart as possible/minimise repulsion ✓</p>	3	3 x 2.5	<p>ALLOW ecf from e(i) DO NOT ALLOW 'repel as much as possible'</p>
5	f		<p>H-Cl/HCl ✓</p>  	3	3 x 2.5	<p>ALLOW unambiguous structural formulae, eg H₂C=CHCl ALLOW correct polymer structure from incorrect monomer IGNORE brackets and 'n' for polymer unit</p>
				20		

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