OCR
Oxford Cambridge and RSA

GCE

Chemistry B

H433/01: Fundamentals of chemistry

A Level

Mark Scheme for June 2022

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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.

MARKING INSTRUCTIONS

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 a tick to confirm that the work has been seen.

7. Award No Response (NR) if:
   - there is nothing written in the answer space.

   Award Zero '0' if:
   - anything is written in the answer space and is not worthy of credit (this includes text and symbols).

   Team Leaders must confirm the correct use of the NR button with their markers before live marking commences and should check this when reviewing scripts.

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 **34(c)** and **35(g)**

11. 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.

Multiple Choice answers

Question	Key	AO
1	B	1.1
2	C	1.1
3	D	1.1
4	B	1.1
5	D	2.1
6	D	1.1
7	D	1.1
8	A	2.1
9	D	1.1
10	A	2.1
11	There was an issue with this question that affected candidates' ability to answer it. To make sure all candidates were treated fairly, we have awarded the mark to all candidates for this question.	2.5
12	D	1.2
13	A	1.1
14	A	1.1
15	B	1.2
16	B	1.1
17	D	2.1
18	A	2.3
19	C	2.4
20	A	2.5
21	B	2.1
22	C	2.6
23	D	2.8
24	D	1.2
25	A	2.3
26	D	2.6
27	C	2.8
28	D	1.2
29	C	2.6
30	D	1.1

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AO element</th><th>Guidance</th></tr>
<tr><td>31</td><td>(a)</td><td></td><td>
<table>
<tr><th>Substance</th><th>Structure</th><th>Bonding</th><th>Melting point</th><th>Electrical conductivity in liquid state</th></tr>
<tr><td>Bromine</td><td>simple molecules</td><td>covalent</td><td>low</td><td>Poor</td></tr>
<tr><td>Sodium bromide</td><td>giant OR lattice</td><td>ionic</td><td>high</td><td>Good/high</td></tr>
</table>
✓ ✓ (one for each correct row)
</td><td>2</td><td>1.1 x 2</td><td>ALLOW 1 mark if structure and bonding correct</td></tr>
<tr><td></td><td>(b)</td><td></td><td>The chlorine gains/attracts an electron more easily (than bromine) ✓

The <u>outer/valence electrons</u> are further from the nucleus/experience weaker nuclear attraction in bromine ORA ✓</td><td>2</td><td>2.1 x 2</td><td>ALLOW the outer electrons in bromine are more shielded than in chlorine</td></tr>
<tr><td></td><td>(c)</td><td></td><td>$2Br^- \rightarrow Br_2 + 2e^{(-)}$ ✓</td><td>1</td><td>1.2</td><td>ALLOW
electron (e) with/without $^{(-)}$ charge
$Br^- \rightarrow \frac{1}{2}Br_2 + e^{(-)}$
IGNORE state symbols</td></tr>
<tr><td></td><td>(d)</td><td></td><td>CHECK ANSWER LINE
If answer rounds to 30 or 31 (cm^3) award 4 marks

Amount of NaBr = 100 / 1000 x (2.57 / 102.9) = 0.00250 mol ✓

Amount of Cl_2 = (0.00250 /2) = 0.00125 mol ✓

V = (0.00125 x 8.314 x [273 + 20]) / 101 000 ✓

V = 0.0000302 m^3
V = 30 (cm^3) ✓</td><td>4</td><td>2.2 x 4</td><td>ALLOW 2 or more sf.

Answer rounding to 60 or 62 cm^3 award 3
If answer rounds to 39cm^3 check for M_r of 79.9 and award 3

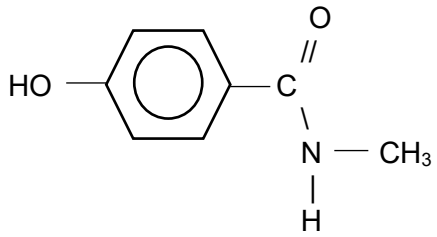
ALLOW ecf throughout</td></tr>
</table>

Question			Answer	Marks	AO element	Guidance
	(e)	(i)	$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ ✓	1	1.2	
	(e)	(ii)	Add <u>concentrated</u> ammonia (solution) ✓ Bromide (partially) soluble **AND** iodide insoluble **AW** ✓	2	1.2 x 2	MP2 depends on use of ammonia
	(f)	(i)	$2HBr + H_2SO_4 \rightarrow SO_2 + Br_2 + 2H_2O$ ✓	1	1.2	
	(f)	(ii)	Use phosphoric acid/H_3PO_4 ✓	1	1.2	
			Total	14		

Question			Answer	Marks	AO element	Guidance
32	(a)		The C-F bond is more polar than the C-C*l* bond as F is more electronegative. **ORA** ✓ The C-Cl bond has a lower bond enthalpy/is weaker/easier to break than the C-F bond. **ORA** ✓ So, chlorine atoms/radicals are released. ✓	**3**	**3.2 x 3**	Some explanation referring to electronegativity needed
	(b)		**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 302 (kJ mol^{-1}) award 4 marks** ν = (3.00 x 10^{8} / 3.96 x 10^{-7}) = 7.576 x 10^{14} Hz ✓ E (per bond) = (6.63 x 10^{-34} x 7.576 x 10^{14}) = 5.023 x 10^{-19} J ✓ E = (5.023 x 10^{-19} x 6.02 x 10^{23}) = 302400 J mol^{-1} E = 302.4 (kJ mol^{-1}) ✓ =302 to 3 sf ✓	**4**	**2.2 x 4**	**ALLOW** 303 from early rounding **ALLOW** ecf throughout **ALLOW** a calculated answer to 3 sf using the data in the question
	(c)	**(i)**	Is in the same state/phase as the reactants. ✓	**1**	**1.1**	
	(c)	**(ii)**	$NO_2 + O \rightarrow NO + O_2$ ✓	**1**	**2.5**	**IGNORE** dots
	(c)	**(iii)**	provides an alternative pathway **AND** of lower activation energy **AW** ✓	**1**	**1.1**	
	(d)	**(i)**	Identity **D** = CH_2Cl_2/dichloromethane **AND E** = C_2H_6/ethane ✓	**1**	**3.1**	

	(d)	**(ii)**	Use of radical(s) that are involved in Reaction 32.1 $CH_3(\bullet)$, $Cl(\bullet)$ or $CH_2Cl(\bullet)$ ✓ Formation of **D** (both propagation $CH_3Cl + Cl(\bullet) \rightarrow CH_2Cl(\bullet) + HCl$ **AND** $CH_2Cl(\bullet) + Cl_2 \rightarrow CH_2Cl_2 + Cl(\bullet)$ **OR** termination $CH_2Cl(\bullet) + Cl(\bullet) \rightarrow CH_2Cl_2$ ✓ Formation of **E** (termination step involving (two) methyl radicals) $2CH_3(\bullet) \rightarrow C_2H_6$ ✓	**3**	**3.2 x 3**	**ALLOW** radicals with or without 'dots'
			Total	**14**		

Question			Answer	Marks	AO element	Guidance
33	(a)		permanent dipole-permanent dipole **OR** instantaneous dipole-induced dipole ✓	1	2.1	**NOT** H-bonds **ALLOW** permanent dipole – induced dipole
	(b)		HOC_6H_4COOH(**s**) + 2NaOH(**aq**) → $NaOC_6H_4COONa$(**aq**) + $2H_2O$(**l**) correct reactants and products with state symbols ✓ completely correct equation ✓	2	1.2	**ALLOW** 1 mark for correctly balanced equation containing $NaOC_6H_4COOH$ **OR** HOC_6H_4COONa **AND** correct state symbols
	(c)	(i)	✓ *for any **two** from:* • effervescence **AW** • powder/solid/4-HBA disappears/dissolves **AW** • a colourless solution (forms) • change in temperature	1	2.7	**ALLOW** Fruity smell (as an ester is formed)
	(c)	(ii)	Any correct structural formula with or without charges HOC_6H_4COONa ✓	1	1.2	If the full equation is shown, it must be correct. Incorrect equation is **CON**
	(d)		Choice of ethanol ✓ Dissolve in minimum volume of hot solvent ✓ Filter when hot and cool/leave to crystallise ✓ Collect crystals by filtering under reduced pressure **AW** ✓ wash (with cold solvent) and dry **AW** ✓	5	3.4 1.2 x 4	Ethanol is only needed for MP1 MP5 depends on presence of solid before washing and drying

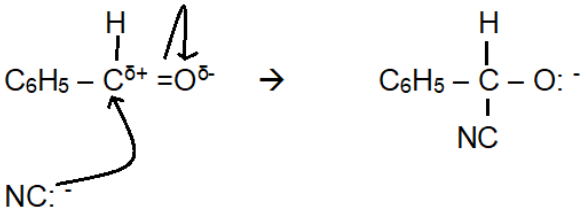
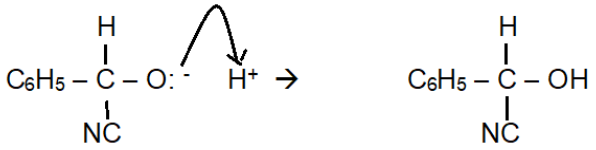
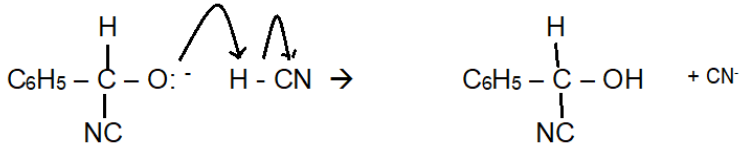
	(e)	**(i)**	Acyl/acid chloride ✓	**1**	**1.1**	
	(e)	**(ii)**	 ✓	**1**	**1.2**	**ALLOW** any structural formula **ALLOW** Kekule structure for ring **ALLOW** substituents in any position **IGNORE** rest of equation if shown
			Total	**12**		

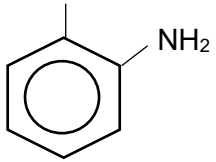
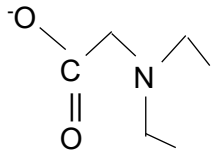
Question			Answer	Marks	AO element	Guidance
34	(a)		Concentrations of reactants and products are constant (not equal) ✓ Forward and reverse reactions still occurring at the same rate ✓ To gain both marks there must be some correct reference to a student's statements	2	3.2 (x2)	
	(b)	(i)	$K_c = [CH_3OH] / [CO][H_2]^2$ ✓	1	1.1	
	(b)	(ii)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 0.106 award 4 marks** $[H_2]^2 = [CH_3OH] / K_c[CO]$ ✓ $[H_2] = \sqrt{0.0290 / (4.75 \times 10^3 \times 0.0481)}$ ✓ $[H_2] = 0.0113$ mol dm^{-3} ✓ $[H_2] = (0.0113 \times (9.40 \times 10^3 / 1000)$ $[H_2] = 0.106$ (mol) ✓	4	2.6 x 4	**ALLOW** ecf throughout **ALLOW** $[H_2] = \sqrt{0.273 / (4.75 \times 10^3 \times 0.452)}$ If MP1, 2 and 3 not scored award 1 mark for correct calculation of concentrations of CO and CH_3OH **ALLOW** 0.11 if correctly rounded from 0.1059 (not 0.113)

	(c)*		Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** Learners give an account of all areas *(with some explanatory points)* *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Learners give an outline account of all areas **OR** Learners give a detailed account of some areas *(with explanatory points from at least two)* *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Learners give an outline account of EITHER yield OR rate for EITHER pressure or temperature *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.* Explanatory points are denoted by an (E)	**6**	**2.1 (x3)** **3.2 (x3)**	**Indicative scientific points include:** **Pressure - yield** • Fewer moles on right/products • High P increases yield of methanol • High P shifts to rhs • *(E) poe shifts to side with fewer moles* • *(E) counteract the change (dec in P)* **Pressure - rate** • High P increases rate of reaction • *(E) reacting particles closer together* • *(E) collide more frequently* **Temperature - yield** • Low T increases yield of methanol • forward reaction is exothermic • Low T shifts to rhs • *(E) Low T poe shifts in direction of exo reaction* • *(E)To counteract the change (increase T)* • *(E) Catalyst has no effect on yield* **Temperature - rate** • Low T decreases rate of reaction • *(E) Collisions are less frequent* • *(E) reacting particles have less energy* • *(E) fewer collisions have required E_a* • *(E) Catalyst allows faster rate at lower T* ***AW*** **Conclusions** • Temperature is compromise rate/yield • Pressure is a compromise due to cost and safety (**AW** throughout)

	(d)	**(i)**	($\Delta_{sys}S$) positive **AND** there are more moles/molecules of (gaseous) products than reactants ✓	**1**	**2.1**	
	(d)	**(ii)**	**CHECK ANSWER LINE** **If answer = 959 K award 4 marks** $\Delta_{sys}S = S_{products} - S_{reactants}$ $\Delta_{sys}S = [(197.6) + 3(130.7)] - [(186.2) + (188.7)]$ $\Delta_{sys}S = [589.4] - [374.9]$ $\Delta_{sys}S = 214.8$ J K^{-1} mol^{-1} ✓ $\Delta_{total}S = 0 = \Delta_{sys}S - \Delta H/T$ ✓ $T = \Delta H / \Delta_{sys}S$ $T = (206 \times 1000) / 214.8$ ✓ T = 959 K ✓	**4**	**2.2 x 4**	**ALLOW** 2 or more sf **ALLOW** ecf throughout $\Delta_{total}S = \Delta_{sys}S + (-\Delta H/T)$, $\Delta_{total}S = 0$ Final temperature must be positive and correctly rounded to score MP4
			Total	**18**		

Question			Answer	Marks	AO element	Guidance
35	(a)		pharmacophore ✓	1	1.1	
	(b)		for one solid wedge and one dashed wedge/line ✓	1	1.1	or one straight line (not at 180 to bond shown) and a dashed line or a wedge. **IGNORE** the rest of the molecule Bond angles, if shown, must be correct
	(c)	(i)	The aluminium(III) chloride reacts (vigorously) with water ✓	1	1.2	
	(c)	(ii)	electrophilic substitution ✓	1	1.1	
	(d)		Reactant: CH_3CH_2OH ✓ Product: H_2O ✓	2	2.5 x 2	
	(e)	(i)	Acidified (potassium) dichromate(VI) **AND** (heat under) reflux ✓	1	1.2	**ALLOW** $Cr_2O_7^{2-}/H^+$
	(e)	(ii)	Warm with Fehling's solution ✓ (solution) turns (from blue) orange/red precipitate ✓ **OR** Warm with Tollens' reagent/ammoniacal silver nitrate ✓ (solution) turns from colourless to silver 'mirror' ✓	2	1.2 x 2	**ALLOW** Benedict's (solution) in place of Fehling's **ALLOW** warm with $Cr_2O_7^{2-}/H^+$ ✓ (orange) to green ✓ Second mark depends on the correct reagent

	(e)	**(iii)**	step 1  Step 2  ✓ both 'curly arrows' in step 1 ✓ partial charges and all full -/+ charges ✓ 'curly arrow' in step 2	**3**	**1.2 x 3**	**ALLOW** step 2 to follow on from step 1 rather than being written separately Curly arrows must start at a lone pair or – charge or the middle of a bond If the structure of the rest of the molecule is incorrect, **ALLOW** ecf on subsequent marks **ALLOW** for step 2 
	(e)	**(iv)**	$H_2SO_4 + HNO_3 \rightarrow HSO_4^- + NO_2^+ + H_2O$ **OR** $2H_2SO_4 + HNO_3 \rightarrow 2HSO_4^- + NO_2^+ + H_3O^+$ ✓	**1**	**1.2**	
	(e)	**(v)**	to prevent loss of reactants/products/mixture **AW** ✓	**1**	**1.2**	

	(f)		Product 1:  ✓ Product 2:  ✓	**2**	**2.5 x 2**	Product 1 and 2 can be in either order. The product must be a carboxylate anion. **ALLOW** salt from suitable alkali

Question	Answer	Mark	AO element	Guidance
(g)*	*Refer to marking instructions on page 5 of mark scheme for guidance on marking this question.* **Level 3 (5 – 6 marks)** Learners use data to work out molecular formula **AND** correctly deduce the structure/identity with evidence from both spectra. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3 – 4 marks)** Learners identify compound correctly but with insufficient working/evidence **OR** Learners give a good account of two areas of the analysis **OR** Learners work out molecular formula correctly and give evidence from both spectra but fail to identify the compound correctly (or do not suggest an identity) *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1 – 2 marks)** Learners give a good account of one area of analysis **OR** Learners attempt a molecular formula calculation and give some evidence from the spectra *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** No response or nothing of value	**6**	**3.1 x 4** **3.2 x 2**	**Indicative scientific points may include:** **AO3.1 Analysis:** **C:H:O mass data** amounts /mol (72.0/12) = 6.00 : (6.70/1) = 6.70 : (21.3/16) = 1.33 ratio /mol (6.00/1.33) = 4.5 : (6.70/1.33) = 5.0 : (1.33/1.33) = 1.0 empirical formula = $C_9H_{10}O_2$ M_r is 150 so molecular formula is $C_9H_{10}O_2$ **H-NMR:** • 4 x H environments (ppm for all data) • 1.4 = HC-C, • 4.5 = HC-O, • 7.5 and 8.0, aromatic H's • Identifies triplet = 2 adjacent H's/CH_2 • Identifies quartet = 3 adjacent H's/CH_3 **C-NMR:** • C=O at about 168 (ppm for all data) • C-O at about 61 • C-C at about 16 • aromatic carbons at 130 • 4 x C peaks meaning monosubstitution **AO3.2 Evaluation:** Compound **H** identified as ethyl benzoate/ $C_6H_5COOCH_2CH_3$ Structure presented in any unambiguous way

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