GCE

Chemistry B

H433/01: Fundamentals of chemistry

A Level

Mark Scheme for June 2024

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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 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 posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **number of required** standardisation responses.

   YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

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 40% 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 or the RM Assessor messaging system, or by email.

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 e-mail.

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(h)** and **35(b)**

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.

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

On additional pages, please annotate using 'SEEN'

11. **Annotations**

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

Annotation	Meaning
I	Ignore
BP	Blank page

12. **Subject Specific Marking Instructions**

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

Annotation	Meaning
I	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
1	D
2	C
3	A
4	D
5	C
6	A
7	C
8	D
9	D
10	B
11	C
12	C
13	B
14	D
15	D
16	B
17	C
18	A
19	A
20	A
21	B
22	A
23	B
24	D
25	C
26	B
27	B
28	B
29	A
30	B

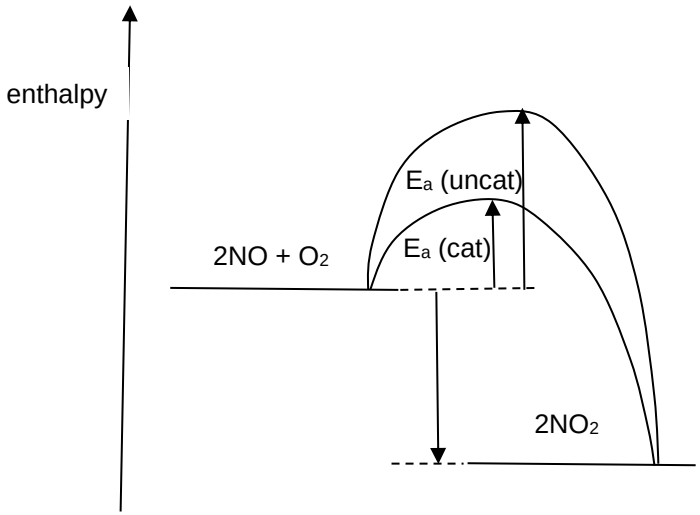
Question			Answer	Marks	Guidance
31	(a)		(apple) green ✓	1	
31	(b)		A series of black lines **AND** on a coloured background ✓ The lines correspond to the same frequencies/wavelength (as those in the emission spectrum) ✓	2	**ALLOW** 'on a background of the continuous spectrum' for 'on a coloured background' **ALLOW** 'in the same positions/superimposable' for 'same frequencies'
31	(c)		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 5.42 x 10^{14} (Hz) award 2 marks** 5.54 x 10^{-5} cm = 5.54 x 10^{-7} m ✓ ($\nu = c / \lambda$) ν = 3.00 x 10^{8} / 5.54 x 10^{-7} = 5.42 x 10^{14} (Hz) ✓	2	**ALLOW** 2 or more sf. **ECF** from no/wrong unit conversion in MP1
31	(d)	(i)	$SrCO_3 \rightarrow SrO + CO_2$ ✓	1	**IGNORE** state symbols
31	(d)	(ii)	First bullet point: Student correct (AW) / $BaCO_3$ decomposes at a higher temperature than $SrCO_3$ (ORA) ✓ Second bullet point: barium **ion**/ Ba^{2+} has a lower charge density (ORA) ✓ barium **ion**/ Ba^{2+} polarises/distorts the carbonate **ion** less (ORA) ✓ **and one from:** ✓ barium **ions**/ Ba^{2+} are not more reactive (ORA) attraction will be less as Ba^{2+} is larger (ORA) energy required to **decompose carbonate** will be greater (ORA)	4	MP2 – 4 must be comparative **ALLOW** barium **ions**/ Ba^{2+} have a smaller charge to radius ratio for MP3

31	**(e)**	**(i)**	Correct use of weighing bottle ✓ Empty MCO_3 and reweigh container (AW) to get mass of MCO_3 ✓	**2**	**ALLOW** alternatives to weighing bottle **ALLOW** use of beaker **ALLOW** Rinse weighing boat with HCl/H_2O **ALLOW** add HCl to beaker if used in MP1
31	**(e)**	**(ii)**	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 84.2 (g mol^{-1}) award 5 marks** n NaOH = (26.15 / 1000 x 0.108) = 2.8242 x 10^{-3} (mol) ✓ n HC*l* left in 25 cm^3 = 2.8242 x 10^{-3} (mol) n HC*l* left in 250 cm^3 = (250 / 25 x 2.8242 x 10^{-3}) = 2.8242 x 10^{-2} (mol) ✓ n HC*l* original = (50.0 / 1000 x 2.00) = 0.100 (mol) ✓ n HC*l* used = (0.100 – 2.8242 x 10^{-2}) = 7.1758 x 10^{-2} (mol) ✓ n MCO_3 = (½ x 7.1758 x 10^{-1}) = 3.5879 x 10^{-2}) mol M MCO_3 = (3.02 / 3.5879 x 10^{-2}) = 84.2 (g mol^{-1}) ✓	**5**	**ALLOW** 2 or more sf **ALLOW** 83.9 - 84.1 from early rounding **ECF** MP1 Moles of NaOH MP2 use of 1:1 ratio and scaling up MP3 moles HCl added MP4 moles HCl used (MP3-MP2) MP5 use of 1:2 ratio and correct evaluation of M_r = mass/moles
31	**(e)**	**(iii)**	0.2 (%) ✓	1	1sf only
			Total	**18**	

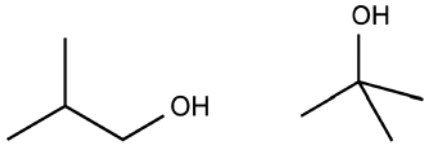
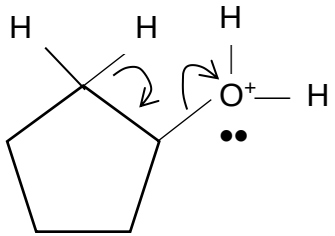
Question			Answer	Mark	Guidance
32	(a)	(i)	show $[NO]^2$ (AW) reasoning linked to experiment 1&2 or values ✓ show [CO] zero order (AW) reasoning linked to experiment 1&3 or values ✓ show $[O_2]$ zero order reasoning linked to experiment 1&4 or values ✓	3	**ALLOW** annotations on the table as reasoning **ALLOW** correct use of any combination of experiments If no reference to experiments or values but correct multiples with reasoning for <u>all three</u> orders of reaction award 1 mark
32	(a)	(ii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 425 AND $dm^3\ s^{-1}\ mol^{-1}$ award 2 marks** $k = rate / [NO_2]^2$ e.g. using Exp't 1, $k = 0.17 / (2.0 \times 10^{-2})^2$ $k = 0.17 / 4.0 \times 10^{-4}$ k = 425 ✓ unit = $mol\ dm^{-3}\ s^{-1} / (mol\ dm^{-3})^2$ = $dm^3\ s^{-1}\ mol^{-1}$ ✓	2	**ALLOW** 2 or more sf **ALLOW** any order in units
32	(b)	(i)	CO is zero order so must be in another step (ORA) **OR** NO_2 must occur twice so cannot be one step (AW) ✓ Possible mechanisms $2NO_2 \rightarrow NO + NO_3$ **AND rds** ✓ $NO_3 + CO \rightarrow NO_2 + CO_2$ ✓ **OR** $2NO_2 \rightarrow 2NO + O_2$ **AND rds** ✓ $CO + NO + O_2 \rightarrow NO_2 + CO_2$ ✓	3	**ALLOW** other feasible reactions involving $2NO_2$ **AND rds** Subsequent steps can be credited IF they lead to overall balanced equation.

32	**(b)**	**(ii)**	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = (+) 147 (kJ mol^{-1}) award 3 marks and check there is a line of best** Line of best fit drawn through points 1 and 4 ✓ Gradient calculated = -17500 ✓ E_a = - Gradient x R = 17500 x 8.314 = 145500 (J mol^{-1}) ✓ = (+) 147 (kJ mol^{-1}) ✓	**4**	**ALLOW** 2 or more sf **ECF** from calculation of gradient from graph LOBF through points 2 and 3 gives E_a = (+)106-115 (kJmol^{-1}) **IGNORE** sign until MP4
			Total	**12**	

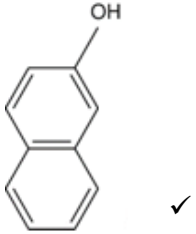
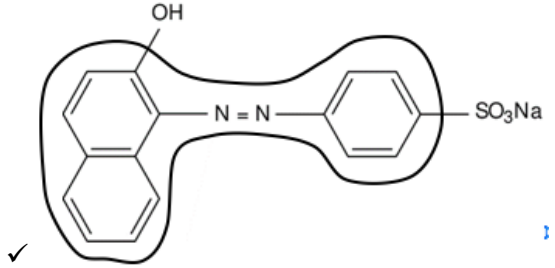
33	**(a)**		brown ✓	**1**	**DO NOT ALLOW** any other colours
33	**(b)**		Warm/ heat with Devarda's alloy/Al and sodium hydroxide/ NaOH ✓ ammonia evolved / gas turns damp red litmus blue ✓	**2**	**ALLOW** add iron(II) sulfate and conc H_2SO_4 forms brown ring for both marks **ALLOW** gas turns indicator paper blue/purple **DO NOT ALLOW** bleaches (litmus or indicator) **MP2 dependent on MP1** **ALLOW** MP2 if Devarda's alloy/Al used **AND** either heat **OR** NaOH used
33	**(c)**	**(i)**	$[NO_2]$ remains constant (AW) ✓ Reaction has not stopped **AND** Rate of forward reaction = rate of back/reverse reaction ✓	**2**	Any reference to [reactants] must be correct if included.
33	**(c)**	**(ii)**	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 2.8 (mol dm^{-3}) award 3 marks** $K_c = [NO_2(g)]^2 / [NO(g)]^2 [O_2(g)]$ ✓ $6.9 \times 10^2 = [NO_2(g)]^2 / (0.250)^2 (0.180)$ $[NO_2(g)] = \sqrt{6.9 \times 10^2 \times 0.01125}$ ✓ $[NO_2(g)] = \sqrt{7.7625}$ $[NO_2(g)] = 2.8$ (mol dm^{-3}) ✓	**3**	**ALLOW** 2 or more sf that rounds to 2.8 **ECF** based on incorrect expression for K_c (provided there are no plus signs in this expression)

33	**(c)**	**(iii)**	The (forward) reaction is exothermic (ORA) ✓ (increase in temperature shifts the position of) equilibrium to the left-hand side (AW) **AND** K_c decreases ✓	2	
33	**(d)**	**(i)**	Catalyst in different state/phase from reactants ✓	**1**	
33	**(d)**	**(ii)**	 $2NO + O_2$ and $2NO_2$ labelled and energy level of reactants > products ✓ Activation enthalpy lines shown with both E_a labelled and E_a (cat) < E_a (uncat) ✓	**2**	**ALLOW** use of intermediate state on catalysed enthalpy profile **ALLOW** double headed arrows **DO NOT ALLOW** just reactants and products on lines **IGNORE** ΔH value if included State symbols not needed but if present must be correct It must be clear that both arrows start from the reactants line
33	**(d)**	**(iii)**	Pt and Rh/they have d electrons (on their surface) ✓ These form weak bonds to the reactants ✓	**2**	**IGNORE** shell number **ALLOW** correct use of chemisorption or adsorption

33	**(e)**		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = (+) 207 (J mol^{-1} K^{-1}) award 4 marks** ($\Delta_{sys}S$ = S(products) – S(reactants)) $\Delta_{sys}S$ = 2(240.0) – (2(210.7) + 205) = 480.0 – (421.4 + 205) = 480.0 – 626.4 = -146.4 (J mol^{-1} K^{-1}) ✓ ($\Delta_{surr}S$ = -(ΔH / T)) $\Delta_{surr}S$ = -(-114.0 x 1000) / (50 + 273)) ✓ = 114000 / 323 = 352.9 (J mol^{-1} K^{-1}) ✓ ($\Delta_{tot}S$ = $\Delta_{sys}S$ + $\Delta_{surr}S$) $\Delta_{tot}S$ = -146.4 + 352.9 = (+) 207 (J mol^{-1} K^{-1}) ✓	**4**	**ALLOW** 2 or more sf MP1 $\Delta_{sys}S$ MP2 $\Delta_{surr}S$, conversion to J and conversion to K MP3 correct evaluation of correct MP2 MP3 subsumes MP2 MP4 $\Delta_{total}S$ **ECF** - 499.3 (J mol^{-1} K^{-1}) scores 2 (MP1 & MP4)
			Total	**19**	

Question			Answer	Mark	Guidance
34	(a)		secondary/2° ✓ OH/ hydroxyl/ alcohol is attached to a carbon atom: to which one hydrogen atom is attached **OR** to which two carbon atoms/ R groups are attached ✓	2	
34	(b)		 ✓ ✓	2	Correct connectivity then **ECF**
34	(c)		Nucleophilic substitution ✓	1	
34	(d)		$CH_3CH_2CH=CH_2$ ✓ $CH_3CH=CHCH_3$ **OR** cis or trans isomer of this ✓ other cis/trans isomer ✓	3	**ALLOW** any unambiguous formulae
34	(e)		 ✓✓ for each 'curly arrow'	2	Extra incorrect arrows **CON** a correct arrow

Question			Answer	Mark	Guidance
34	(f)*		*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)** Correct formulae with main points from all spectra and most fine detail including reference to splitting and justification for primary alcohol. *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)** Correct formulae with some main points and/or fine detail **OR** One correct formula with most main points and fine detail. . *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)** One correct formula with little relevant evidence. **OR** Some main points and/or fine detail. *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	**6**	**Indicative scientific points include** *fine detail points in italic* **Mass spectrum** • M_r = 60 • *peak at 31 is –CH_2OH/ or difference 60-31 is C_2H_5* **IR spectra of A and B** • Peak 3200-3600cm^{-1} for A shows alcohol O-H • Peak 2500-3300cm^{-1} for B shows acid O-H • *Peak 1700cm^{-1} for B shows C=O* **NMR spectrum of A** • 4 peaks 4 proton environments / 3 CH peaks • *triplet δ = 0.9 due to C**H**$_3$–CH_2–* • *multiplet (sextet) δ = 1.5 due to CH_3–C**H**$_2$–CH_2O* • *triplet δ = 3.5 due to C**H**$_2$-O region* • *triplet **H**$_2$C–O so 1^o alcohol* **Identification** **A** is $CH_3CH_2CH_2OH$ **B** is CH_3CH_2COOH • *A must be primary alcohol as B is carboxylic acid* *Well-developed lines of reasoning could include some of:* • *The splitting pattern to build the structure* • *Fragmentation to build the structure* • *Considered reasoning for primary alcohol* • *Clear links between points*
			Total	**16**	

Question			Answer	Mark	Guidance
35	(a)	(i)	benzenesulfonic acid ✓	1	
	(a)	(ii)	SO_3 ✓	1	
	(b)		Sn/tin and conc(entrated) hydrochloric acid/HCl **AND** heat/reflux ✓	1	
	(c)		Sodium nitrate(III)/ sodium nitrite/ $NaNO_2$ ✓ hydrochloric acid/HCl ✓ < 5^o / ice (bath) ✓	3	**ALLOW** Nitric(III) acid/nitrous acid/HNO_2 Ignore concentrated (HCl) **DO NOT ALLOW** other acids
	(d)		 ✓	1	**ALLOW** any unambiguous structural formula Ignore structures with delocalised electron rings
35	(e)	(i)	 ✓	1	**ALLOW** inclusion O of OH **ALLOW** inclusion of SO_3 of SO_3Na
35	(e)	(ii)	$-SO_3Na$/ $-SO_3^-$ ✓	1	**ALLOW** without bond to S

Question			Answer	Mark	Guidance
35	(f)*		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 provide **MOST** points from all three areas including outline of reaction conditions and description of mechanism for reaction with bromine and reference to delocalised electrons above and below the C ring *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 provide **MOST** points from two areas **OR** **SOME** points from all three areas *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 provide **SOME** points *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.*	6	**Indicative scientific points include** **Explanation of data (AO1.2)** • Benzene is more (energetically) stable, (by 152 kJ mol^{-1}) • The Kekulé structure would have $\Delta_{hydrogenation}H = 3(-120) = -360$ kJ mol^{-1} (May be shown on an enthalpy level diagram). **Different model (AO1.1)** In benzene: • six carbon electrons are delocalised/ one electron from each carbon atom is delocalised. • electrons shared by all six carbon atoms to forms rings. • electrons above and below carbon ring/ in p orbitals which overlap/ π bonding system **Reaction with bromine (AO1.1)** • Benzene undergoes electrophilic substitution. • $C_6H_6 + Br_2 \rightarrow C_6H_5Br + HBr$ • Delocalised electrons are retained in product • Need halogen carrier/ $FeBr_3$/ $Fe + Br_2$ • The Kekulé structure would undergo electrophilic addition. • eg $C_6H_6 + Br_2 \rightarrow C_6H_6Br_2$ (or more bromines adding) • One (or more) C=C becomes saturated. *Well-developed lines of reasoning could include:* • *Clear links between points*
			Total	15	

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