



GCE

Chemistry B

H433/01: Fundamentals of chemistry

Advanced GCE

Mark Scheme for June 2019

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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.

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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

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

Annotation	Meaning
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

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.

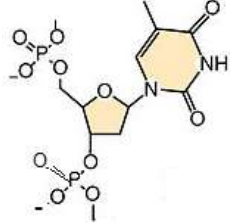
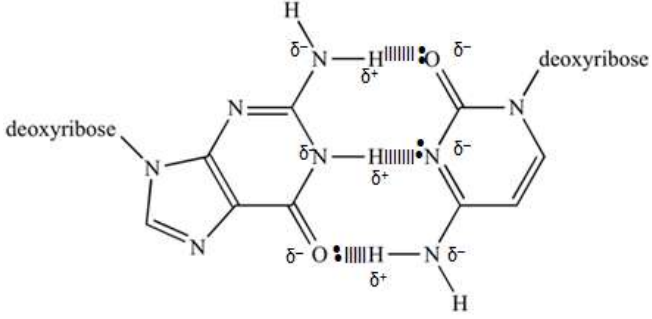
Section A

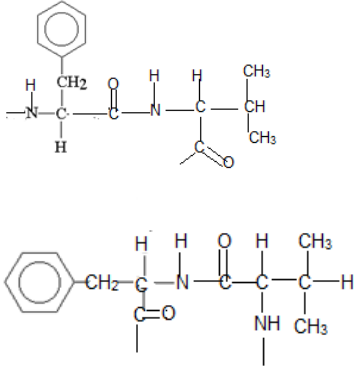
Q	Key	Mark	AO element	
1	C	1	1.1	
2	A	1	1.1	
3	A	1	1.1	
4	B	1	1.1	
5	D	1	2.2	
6	D	1	2.8	
7	D	1	1.1	
8	C	1	1.1	
9	A	1	1.1	
10	C	1	2.2	
11	C	1	1.1	
12	C	1	2.5	
13	D	1	1.1	
14	B	1	1.1	
15	C	1	1.1	
16	C	1	2.2	
17	A	1	1.1	
18	A	1	2.6	
19	D	1	2.8	
20	B	1	2.8	
21	A	1	2.8	
22	B	1	1.1	
23	A	1	1.1	
24	B	1	2.2	
25	C	1	2.2	
26	C	1	2.8	
27	D	1	1.1	
28	C	1	1.1	
29	B	1	1.1	
30	C	1	1.1	

Question		Answer	Marks	AO element	Guidance
31	(a)	<p>Any 2 of:</p> <p>Rate of forward reaction = rate of reverse ✓</p> <p>closed system ✓</p> <p>Overall concentrations remain constant OR the same BUT NOT concentrations ARE the same ✓</p>	2	1.1	Any 2 out of 3 mps
31	(b)	<p>FIRST CHECK ANSWER ON ANSWER LINE If answer = 5.0 (mol dm⁻³) award 3 marks</p> <p>$K_c = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$ ✓</p> <p>Substitution of concentrations AND re-arrangement $x^2 = 3 \times 2 \times 1.6^3 (= 24.576)$ ✓</p> <p>Evaluation, $x = (\sqrt{24.567}) = 5.0 \text{ (mol dm}^{-3}\text{)}$ ✓</p>	3	2.6 x 3	<p>ALLOW 2 or more sf any answer rounding to 5.0</p> <p>1.65 scores 2 (inverted K_c)</p>
31	(c)	<p>If ammonia is removed [NH₃]/product decreases ✓</p> <p>(Position of) eqm shifts to right/products to maintain K_c (AW) ✓</p>	2	3.1 x 2	2 nd mark dependent on 1 st mark

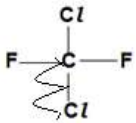
Question			Answer	Marks	AO element	Guidance
31	(d)*	(i)	<p>Level 3 (5–6 marks) Detailed description of each condition of temperature, pressure and catalyst, both in their effect on rate and yield/position of eqm</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured.</i></p> <p>Level 2 (3–4 marks) Detailed description of least two conditions of temperature, pressure or catalyst, both in their effect on rate and yield/position of eqm. OR Outline description of each condition of temperature, pressure and catalyst, BOTH rate and yield/position of eqm MUST be considered for at least ONE condition.</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) Detailed description of one of the conditions of temperature, pressure or catalyst, both in their effect on rate and yield/position of eqm. OR Outline description of each condition of temperature, pressure and catalyst, in their effect on rate OR yield/position of eqm.</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 No response or no response worthy of credit.</p>	6	3.2 x 6	<p>Indicative scientific points may include:</p> <p>Temperature:</p> <ul style="list-style-type: none"> • Reaction is exothermic • A lower temperature would have given a greater yield • BUT too low a temperature decreases rate • As a smaller frequency of collisions have $E \geq E_A$ • 500K is a compromise between rate and yield AW <p>Pressure:</p> <ul style="list-style-type: none"> • Fewer moles on reactant side (9 → 10) (AW) • Greater yield at low pressure • rate would be higher at higher P • collisions are more frequent. <p>Catalyst:</p> <ul style="list-style-type: none"> • Catalyst lowers E_A, • so faster rate of reaction OR achieving eqm • more frequent successful collisions • No effect on position of eqm • BUT a reasonable rate at lower T, better for yield. <p>IGNORE references to cost or safety for all conditions</p> <p>IGNORE references to equations 31.3 and 31.4, credit can only be giving for statements correctly referencing equation 31.2</p>
31	(d)	(ii)	Fewer moles gas (3 → 2) AND so ΔS_{sys} is negative (AW)	3	1.1 x 2	If ΔS_{sys} is given as positive only mp 3 is available.

Question		Answer	Marks	AO element	Guidance
		<p>(ORA) ✓</p> <p>$\Delta S_{\text{tot}} = \Delta S_{\text{sys}} - \Delta H/T$ must be positive for the reaction to be favourable ✓</p> <p>As T increases $-\Delta H/T$ becomes less positive so reaction becomes less feasible at higher T (AW) (ORA) ✓</p>		2.1 x 1	<p>For mp2 must quote $\Delta S_{\text{tot}} = \Delta S_{\text{sys}} - \Delta H/T$</p> <p>OR $\Delta S_{\text{tot}} = \Delta S_{\text{sys}} + \Delta S_{\text{surr}}$ AND $\Delta S_{\text{surr}} = -\Delta H/T$</p>

Question	Answer	Mark	AO element	Guidance
32 (a)	 <p>BOTH bonds between phosphate and sugar ✓</p> <p>Bond between sugar and base ✓</p> <p>All other details correct ✓</p>	3	1.2 x 3	ALLOW phosphates with minus sign or 'spare bonds' or -OH groups
32 (b)	 <p>3-H bonds ✓</p> <p>3 partial charges across at least 1 H-bond ✓</p> <p>Lone pair along the bond axis in at least 1 H-bond ✓</p>	3	1.2 x 3	any other number of H-bonds is CON

Question		Answer	Mark	AO element	Guidance
32	(c)	 <p>Amide link between phenylamine and valine ✓</p> <p>Rest of structure ✓</p>	2	2.5	<p>ALLOW either structure</p> <p>MUST have spare bonds at the ends of the section to score second mp</p> <p>IGNORE brackets around entire unit</p>

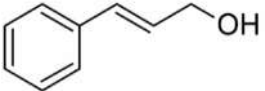
32	(d)*	<p>Level 3 (5–6 marks) Detailed explanation of how the enzyme and inhibitor work in general AND relates these ideas to the structures of the molecules given.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured.</i></p> <p>Level 2 (3–4 marks) Detailed explanation of how the enzyme and inhibitor work in general. OR An attempt at an explanation of how the enzyme and inhibitor work in general AND relates these ideas to the structures of the molecules 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) Detailed explanation of how the enzyme works in general. OR Detailed explanation of how the inhibitor work in general. OR An attempt at an explanation of how the enzyme and inhibitor work in general. OR An attempt to relate how enzymes work to ideas to the structures of the molecules 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 No response or no response worthy of credit.</p>	6	2.2 x 4 3.1 x 2	<p>Indicative scientific points may include:</p> <p>How the enzyme works, general comments:</p> <ul style="list-style-type: none"> • Substrate fits/binds into the active site • Substrate has complementary shape to active site (ORA) • Bonds weaken/Lowers E_A/biological catalyst • Substrate reacts • Products leave the active site <p>How the inhibitor works, general comments:</p> <ul style="list-style-type: none"> • Inhibitor has a similar shape to the substrate (AW) • so it also fits into the active site • It blocks the active site/doesn't release • substrate cannot bind (and react) • Fewer/ no active sites available to the substrate so slower/ no reaction <p>Comments specific to these molecules:</p> <ul style="list-style-type: none"> • Example of where these molecules share some of the same shapes (check for annotation on the diagram) • Middle part of the molecule has similar shape • Example of intermolecular interaction between these molecules and enzyme • Substrate has amide bond that can be hydrolysed, and products leave • Inhibitor has no amide bond (in the same place) so does not react and leave • Comments on other differences that may affect the binding of the inhibitor vs substrate.
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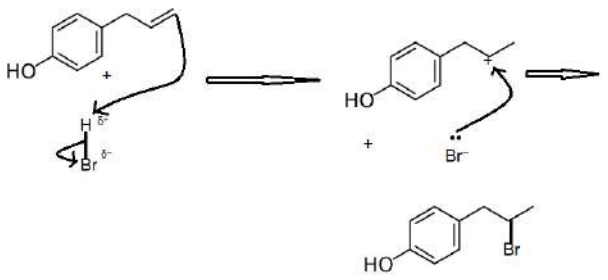
Question		Answer				Mark	AO element	Guidance																				
33	(a)	<p>FIRST CHECK ANSWER ON ANSWER LINE If answer = 363 (kJ mol⁻¹) award 3 marks</p> <p>$E = hc/\lambda$ or 6.03×10^{-19} ✓</p> <p>Ans x 6.02×10^{23} (= 363000 J) ✓</p> <p>= 363 (kJ mol⁻¹) ✓</p>				3	2.4 x 3	<p>Allow 2 or more sf</p> <p>Expression for energy per bond or evaluated</p> <p>x Avogadro constant → energy per mole</p> <p>Evaluation and conversion to kJ mol⁻¹</p> <p>Common errors</p> <p>1.32×10^{-16} scores 1 (using λ instead of ν)</p> <p>1.32×10^{-19} scores 2</p> <p>6.03×10^{-22} scores 2</p>																				
	(b)	 <p>2 single headed arrows to either Cl atom AND Homolytic fission ✓</p>				1	1.2	If products are given they must be correct																				
33	(c)	<table border="1"> <thead> <tr> <th>Reaction</th> <th>Initiation</th> <th>Propagation</th> <th>Termination</th> </tr> </thead> <tbody> <tr> <td>$CCl_2 \rightarrow CCl$ $F_2 + Cl$</td> <td>✓</td> <td></td> <td></td> </tr> <tr> <td>$Cl + O_3 \rightarrow ClO$ $+ O_2$</td> <td></td> <td>✓</td> <td></td> </tr> <tr> <td>$ClO + O \rightarrow Cl$ $+ O_2$</td> <td></td> <td>✓</td> <td></td> </tr> <tr> <td>$Cl + Cl \rightarrow$ Cl_2</td> <td></td> <td></td> <td>✓</td> </tr> </tbody> </table> <p>All correct ✓ ✓ 2 or 3 correct ✓</p>	Reaction	Initiation	Propagation	Termination	$CCl_2 \rightarrow CCl$ $F_2 + Cl$	✓			$Cl + O_3 \rightarrow ClO$ $+ O_2$		✓		$ClO + O \rightarrow Cl$ $+ O_2$		✓		$Cl + Cl \rightarrow$ Cl_2			✓				2	2.5 x 2	
Reaction	Initiation	Propagation	Termination																									
$CCl_2 \rightarrow CCl$ $F_2 + Cl$	✓																											
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$ClO + O \rightarrow Cl$ $+ O_2$		✓																										
$Cl + Cl \rightarrow$ Cl_2			✓																									

Question			Answer	Mark	AO element	Guidance
33	(d)	(i)	FIRST CHECK ANSWER ON ANSWER LINE If answer = 7.8×10^{-4} (mol) award 2 marks Use of $n = PV/RT$ ✓ $n = (1100 \times 1.5 \times 10^{-3}) / (8.314 \times 253) = 7.84 \times 10^{-4}$ (mol) ✓	2	2.6 x 2	ALLOW 2 or more sf
33	(d)	(ii)	FIRST CHECK ANSWER ON ANSWER LINE If answer is 20 (cm³) award 2 marks Use of $V = nRT/P$ ✓ Ans to (d)(i) $\times 8.314 \times 298/97 \times 10^3 = 2.00 \times 10^{-5} \text{ m}^3 = 20(\text{cm}^3)$ (2sf) ✓	2	2.6 x 2	Allow ECF from 33 d (i) Mp2 is only scored if answer is given to 2sf
33	(e)	(i)	Oxygen and nitrogen from the air ✓ react in the high temp in engine ✓	2	1.1	ALLOW 'heat' for high temperature IGNORE 'pressure'
33	(e)	(ii)	Brown (gas) ✓	1	1.1	ALLOW 'goes brown' (AW)
33	(f)	(i)	Aldehyde ✓	1	1.1	IGNORE 'carbonyl'
33	(e)	(ii)	$(-)\text{CHO} + \text{HCN} \rightarrow (-)\text{CH}(\text{OH})(\text{CN})$ ✓	1	2.5	ALLOW any unambiguous structure

Question		Answer	Mark	AO element	Guidance
34	(a)	$1\text{H} + 1\text{H} \rightarrow 2\text{He} + \gamma$ $2\text{He} + 2\text{He} \rightarrow 4\text{He} + 1\text{H}.. + 1\text{H}..$ <p>The 2 product hydrogen atoms (correct numbers must be on the left) ✓</p> <p>The rest correct ✓</p>	2	2.5 x 2	<p>Mark each point separately</p> <p>Ignore γ but any other radiation is CON</p> <p>Use of 'p' instead of H is acceptable in the product NOT P</p>
34	(b)	<p>Dot and cross diagram ✓</p> <p>One bond angle round C 109.5° ✓</p> <p>One bond angle round N 107° ✓</p>	3	2.1 x 3	<p>NOT 109° or 107.5°</p> <p>NO ECF on incorrect structure and bond angle</p> <p>NOT between lone pair and bonding pair</p>
34	(c)	<p>FIRST CHECK ANSWER ON ANSWER LINE If answer = $-1273.3 \text{ (kJmol}^{-1}\text{)}$ award 3 marks</p> <p>Correct multiplication of ΔH_f values ✓</p> <p>$6(-285.8) + x - 6(-393.5) - 12(-20.6) = -379.9$ OR $x = -379.9 + 6(285.8) - 6(393.5) - 12(20.6)$ ✓</p> <p>Evaluation with sign ✓</p>	3	2.6 x 3	<p>Mp1 $6(-285.8) = -1714.8$ AND $6(-393.5) = -2361$ $12(-20.6) = -247.2$ OR $-2361 + -247.2 = -2608.2$</p> <p>Mp2 Correct expression of correct ΔH values</p> <p>-893.4 scores 2 (no use of ΔH_f) (+)1273.3 scores 2 (Incorrect sign) (+)839.4 scores 1</p>
34	(d)	$1s^2 2s^2 2p^6 3s^2 3p^6$ ✓	1	1.1	<p>[Ne]... or [Ar] score 0. e numbers must be superscript and shell designation must be lower case.</p>

Question			Answer	Mark	AO element	Guidance
34	(e)	(i)	Starch AND blue/black to colourless ✓	1	1.2	NOT purple
34	(e)	(ii)	<p>FIRST CHECK ANSWER ON ANSWER LINE If answer = 24.1 (mg dm⁻³) award 3 marks</p> <p>Ratio thio: Cu²⁺ is 1:1 AND moles thio is $0.95 \times 0.02/1000 = 1.9 \times 10^{-5}$ ✓</p> <p>Moles Cu²⁺ per dm³ = $1.9 \times 10^{-5} \times 1000/50 = 3.8 \times 10^{-4}$ ✓</p> <p>Mass Cu²⁺ is answer $\times 63.5 \times 1000$ (mg) ✓</p>	3	2.8 x 3	<p>ALLOW two or more sf</p> <p>Moles thio AND ratio thio: Cu²⁺ (may be implied)</p> <p>Moles Cu²⁺ per dm³</p> <p>Mass Cu²⁺ and conversion to mg</p> <p>3.8 x 10⁻⁴ on answer line scores 2 1.9 x 10⁻⁵ on answer line does not score mp1 unless ratio to Cu²⁺ ions is clearly stated or implied</p>
34	(e)	(iii)	$0.1 \times 100/0.95 = 10.5 / 11$ (%)	1	2.8	ALLOW 2 or more sf rounding to 11
34	(e)	(iv)	<p>Dilute their thiosulfate by a factor of 20 to give a titre of approx. 19 cm³ ✓</p> <p>Use a (volumetric) pipette to withdraw 50 cm³ into a volumetric flask and make up to the mark with water ✓</p>	2	3.4 3.3	<p>ALLOW a dilution factor consistent with answer to 34 e(iii)</p> <p>ALLOW use more seawater as long as 1dm³ is specified (either directly or by calculation.)</p> <p>If 34 e(iii) is incorrect ALLOW volume of seawater consistent with the error.</p> <p>(This option precludes access to mp2) Method of doing the dilution, ALLOW any final volume of solution of 100 cm³ or above.</p>

Question		Answer				Mark	AO element	Guidance																			
35	(a)	Orange/brown to colourless ✓				1	1.1	IGNORE yellow																			
35	(b)	Contains a benzene ring ✓				1	1.1	ALLOW arene, IGNORE phenol NOT conjugated/delocalised ring/cyclic system without further qualification Hydrocarbon is a CON																			
35	(c)	(neutral) iron(III) chloride/FeCl ₃ AND (orange to) purple (AW) ✓				1	1.1	ALLOW iron(III) nitrate/Fe(NO ₃) ₃ if starting colour is given it must be orange or brown, any other colour is CON																			
35	(d)	(i)	<table border="1"> <thead> <tr> <th></th> <th>Reagent</th> <th>Conditions</th> <th>Colour change</th> </tr> </thead> <tbody> <tr> <td>Oxidation Alcohol</td> <td>Cr₂O₇²⁻/ H⁺</td> <td>Distil</td> <td>Orange to green</td> </tr> <tr> <td rowspan="2">Aldehyde or ketone</td> <td>Tollen's/ Ammoniacal Ag⁺</td> <td>Warm</td> <td>(Appearance of) Silver mirror (AW)</td> </tr> <tr> <td>OR Fehling's (A and B) / Benedict's OR Cr₂O₇²⁻/ H⁺</td> <td>Heat</td> <td>Blue → brick red</td> </tr> <tr> <td></td> <td></td> <td>Heat under reflux</td> <td>Orange → green</td> </tr> </tbody> </table>				Reagent	Conditions	Colour change	Oxidation Alcohol	Cr ₂ O ₇ ²⁻ / H ⁺	Distil	Orange to green	Aldehyde or ketone	Tollen's/ Ammoniacal Ag ⁺	Warm	(Appearance of) Silver mirror (AW)	OR Fehling's (A and B) / Benedict's OR Cr ₂ O ₇ ²⁻ / H ⁺	Heat	Blue → brick red			Heat under reflux	Orange → green	3	1.2 x 3	1 mark per column of table correct OR if no complete column can score 1 for a fully correct row ALLOW acidified (potassium or sodium) dichromate as reagent in either or both tests. If another specific dichromate is identified it must be soluble. Formula must be correct. In second row, if a silver salt is named it must be soluble. For Fehling's solution or Benedict's solution ALLOW orange
	Reagent	Conditions	Colour change																								
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35	(d)	(ii)				1	1.1																				
35	(e)	(i)	H ₂ , Ni 'heat and pressure' (or specified sensible values) OR H ₂ , Pt, room temp ✓			1	1.1	ALLOW Ni/Pt as reagent or conditions Any other reagent is a CON																			

35	(f)	(ii)	<p>The dehydration of the secondary alcohol could give the double bond either in the new position or the original position ✓</p> <p>A mixture of products (AW) ✓</p>	2	3.2 x 2	<p>IGNORE references to position of equilibrium.</p> <p>Clear implication that both isomers would form is required for mp2</p>
35	(g)	(i)	 <p>Both curly arrows and partial charges on HBr ✓</p> <p>Intermediate and attack of Br⁻ ✓</p>	2	1.2 x 2	<p>Curly arrows must start on the bond concerned (or the lone pair or minus sign of Br⁻). They must point to the atom concerned or the bond that is to be formed.</p> <p>ALLOW R- for rest of structure</p> <p>Lone pair is not required on Br⁻ but if not present curly arrow must start at minus sign.</p> <p>Product is not required but if it is shown it must be correct for mp2</p> <p>A valid mechanism leading to the anti Markownikov product scores 1</p>
35	(g)	(ii)	<p>H must add first (in either reaction) ✓</p> <p>Product 1 cannot form as H^{δ+} as it is the only electrophile (ORA) ✓</p> <p>Product 2 could form as Cl⁻ can react with the carbocation (once the H^{δ+} has reacted) ✓</p>	3	3.2 x 3	<p>Mp1 for clear implication of electrophilic reaction involving HBr</p> <p>Mp2 for identifying H^{δ+} as the only electrophile OR by stating that Br⁻ AND H₂O (NOT OH⁻) are nucleophiles / not electrophiles. (IGNORE Cl⁻)</p> <p>IGNORE comments comparing reactivity or steric factors in halide ions for mp3</p>

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