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.

Annotations available in RM Assessor

Annotation	Meaning
	Correct response
	Incorrect response
	Omission mark
BOD	Benefit of doubt given
CON	Contradiction
RE	Rounding error
SF	Error in number of significant figures
ECF	Error carried forward
L1	Level 1
L2	Level 2
L3	Level 3
NBOD	Benefit of doubt not given
SEEN	Noted but no credit given
I	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.

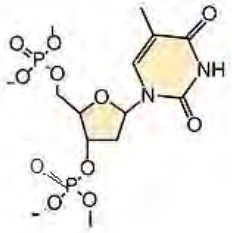
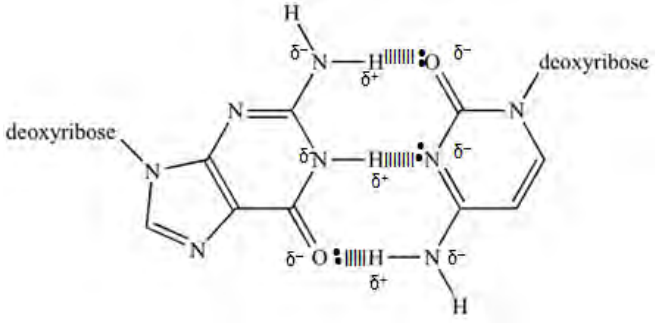
Section A

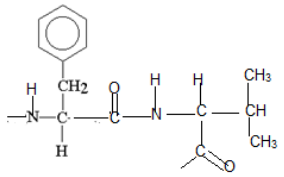
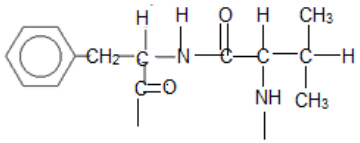
Q	Key	Mark	AO element	
1	C	1	1.1	
2	A	1	1.1	
3	A	1	1.1	
4	B	1	1.1	
5	D	1	2.2	
6	D	1	2.8	
7	D	1	1.1	
8	C	1	1.1	
9	A	1	1.1	
10	C	1	2.2	
11	C	1	1.1	
12	C	1	2.5	
13	D	1	1.1	
14	B	1	1.1	
15	C	1	1.1	
16	C	1	2.2	
17	A	1	1.1	
18	A	1	2.6	
19	D	1	2.8	
20	B	1	2.8	
21	A	1	2.8	
22	B	1	1.1	
23	A	1	1.1	
24	B	1	2.2	
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)		Any 2 of: Rate of forward reaction = rate of reverse ✓ closed system ✓ Overall concentrations remain constant **OR** the same **BUT NOT** concentrations **ARE** the same✓	**2**	**1.1**	Any 2 out of 3 mps
31	(b)		**FIRST CHECK ANSWER ON ANSWER LINE** **If answer = 5.0 (mol dm^{-3}) award 3 marks** $K_c = [NH_3]^2 / [N_2][H_2]^3$ ✓ Substitution of concentrations **AND** re-arrangement $x^2 = 3 \times 2 \times 1.6^3$ (= 24.576) ✓ Evaluation, $x = (\sqrt{24.567}) = 5.0$ (mol dm^{-3}) ✓	**3**	**2.6 x 3**	**ALLOW** 2 or more sf any answer rounding to 5.0 1.65 **scores 2** (inverted K_c)
31	(c)		If ammonia is removed **[NH_3]/product** decreases ✓ (Position of) eqm shifts to right/products to maintain K_c (AW) ✓	**2**	**3.1 x 2**	2nd mark dependent on 1st mark

Question			Answer	Marks	AO element	Guidance
31	(d)*	(i)	**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 *There is a well-developed line of reasoning which is clear and logically structured.* **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. *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)** 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. *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**	**3.2 x 6**	**Indicative scientific points may include:** **Temperature:** • 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≥ E_A • 500K is a compromise between rate and yield **AW** **Pressure:** • Fewer moles on reactant side (9 → 10) (**AW**) • Greater yield at low pressure • rate would be higher at higher P • collisions are more frequent. **Catalyst:** • 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. **IGNORE** references to cost or safety for all conditions **IGNORE** references to equations 31.3 and 31.4, credit can only be giving for statements correctly referencing equation 31.2
31	(d)	(ii)	Fewer moles gas (3 → 2) **AND** so ΔS_{sys} is negative (**AW**)	**3**	**1.1 x2**	If ΔS_{sys} is given as positive only mp 3 is available.

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

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

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

32	**(d)***		**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. *There is a well-developed line of reasoning which is clear and logically structured.* **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. *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)** 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. *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**	**2.2 x 4** **3.1 x 2**	**Indicative scientific points may include:** **How the enzyme works, general comments:** • 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 **How the inhibitor works, general comments:** • 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 **Comments specific to these molecules:** • **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.

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>AO element</th><th>Guidance</th></tr>
<tr><td>33</td><td>(a)</td><td></td><td>FIRST CHECK ANSWER ON ANSWER LINE
If answer = 363 (kJ mol^{-1}) award 3 marks

E = hc/λ or 6.03 x 10^{-19} ✓

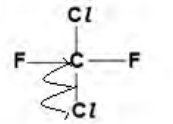
Ans x 6.02 x 10^{23} (= 363000 J) ✓

= 363 (kJ mol^{-1}) ✓</td><td>3</td><td>2.4 x 3</td><td>Allow 2 or more sf

Expression for energy per bond or evaluated

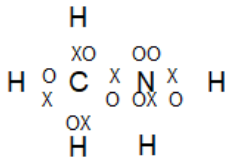
x Avogadro constant → energy per mole

Evaluation and conversion to kJ mol^{-1}

Common errors
1.32 x 10^{-16} scores 1 (using λ instead of v)
1.32 x 10^{-19} scores 2
6.03 x 10^{-22} scores 2</td></tr>
<tr><td></td><td>(b)</td><td></td><td> 

2 single headed arrows to either Cl atom AND
Homolytic fission ✓</td><td>1</td><td>1.2</td><td>If products are given they must be correct</td></tr>
<tr><td>33</td><td>(c)</td><td></td><td>
<table>
<tr><th>Reaction</th><th>Initiation</th><th>Propagation</th><th>Termination</th></tr>
<tr><td>CCl$_2$ → CClF$_2$ + Cl</td><td>✓</td><td></td><td></td></tr>
<tr><td>Cl + O$_3$ → ClO + O$_2$</td><td></td><td>✓</td><td></td></tr>
<tr><td>ClO + O → Cl + O$_2$</td><td></td><td>✓</td><td></td></tr>
<tr><td>Cl + Cl → Cl$_2$</td><td></td><td></td><td>✓</td></tr>
</table>
All correct ✓ ✓
2 or 3 correct ✓</td><td>2</td><td>2.5 x 2</td><td></td></tr>
</table>

Question			Answer	Mark	AO element	Guidance
33	**(d)**	**(i)**	**FIRST CHECK ANSWER ON ANSWER LINE** **If answer = 7.8 x 10^{-4} (mol) award 2 marks** Use of n = PV/RT ✓ n =(1100 x 1.5 x 10^{-3})/8.314 x 253 = 7.84 x 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 (cm^3) award 2 marks** Use of V = nRT/P ✓ Ans to (d)(i) x 8.314 x 298/97 x 10^3 = 2.00 x 10^{-5} m^3 = 20(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)**	(–)CHO + HCN → (–)CH(OH)(CN) ✓	**1**	**2.5**	**ALLOW** any unambiguous structure

Question			Answer	Mark	AO element	Guidance
34	(a)		$^{1}_{1}H + {}^{1}_{1}H \rightarrow {}^{2}_{1}He + \gamma$ $^{3}_{2}He + {}^{3}_{2}He \rightarrow {}^{4}_{2}He + {}^{1}_{1}H + {}^{1}_{1}H$ The 2 product hydrogen atoms (correct numbers must be on the left) ✓ The rest correct ✓	2	2.5 x 2	Mark each point separately Ignore γ but any other radiation is **CON** Use of 'p' instead of H is acceptable in the product **NOT** P
34	(b)		 Dot and cross diagram ✓ One bond angle round C 109.5^0 ✓ One bond angle round N 107^0 ✓	3	2.1 x3	**NOT** 109^0 or 107.5^0 **NO** ECF on incorrect structure and bond angle **NOT** between lone pair and bonding pair
34	(c)		**FIRST CHECK ANSWER ON ANSWER LINE** **If answer = -1273.3 ($kJmol^{-1}$) award 3 marks** Correct multiplication of ΔHf values ✓ 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) ✓ Evaluation with sign ✓	3	2.6 x 3	Mp1 6(-285.8) = -1714.8 **AND** 6(-393.5) = -2361 12(- 20.6) = -247.2 **OR** -2361 + -247.2 = -2608.2 Mp2 Correct expression of correct ΔH values -893.4 **scores 2** (no use of ΔH_r) (+)1273.3 **scores 2** (Incorrect sign) (+) 839.4 **scores 1**
34	(d)		$1s^2 2s^2 2p^6 3s^2 3p^6$ ✓	1	1.1	[Ne]... or [Ar] score 0. e numbers must be superscript and shell designation must be lower case.

Question			Answer	Mark	AO element	Guidance
34	(e)	(i)	Starch **AND** blue/black to colourless ✓	1	1.2	**NOT** purple
34	(e)	(ii)	**FIRST CHECK ANSWER ON ANSWER LINE** **If answer = 24.1 (mg dm^{-3}) award 3 marks** Ratio thio: Cu^{2+} is 1:1 **AND** moles thio is 0.95 x 0.02/1000 = 1.9 x 10^{-5} ✓ Moles Cu^{2+} per dm^3 = 1.9 x 10^{-5} x1000/50 =3.8 x 10^{-4} ✓ Mass Cu^{2+} is answer x 63.5 x1000 (mg) ✓	3	2.8 x 3	**ALLOW** two or more sf Moles thio **AND** ratio thio: Cu^{2+} (may be implied) Moles Cu^{2+} per dm^3 Mass Cu^{2+} and conversion to mg 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 Cu^{2+} ions is clearly stated or implied
34	(e)	(iii)	0.1 x 100/0.95 =10.5 / 11 (%)	1	2.8	**ALLOW** 2 or more sf rounding to 11
34	(e)	(iv)	Dilute their thiosulfate by a factor of 20 to give a titre of approx. 19 cm^3 ✓ Use a (volumetric) pipette to withdraw 50 cm^3 into a volumetric flask and make up to the mark with water ✓	2	3.4 3.3	**ALLOW** a dilution factor consistent with answer to 34 e(iii) **ALLOW** use more seawater as long as 1dm^3 is specified (either directly or by calculation.) If 34 e(iii) is incorrect **ALLOW** volume of seawater consistent with the error. (This option precludes access to mp2) Method of doing the dilution, **ALLOW** any final volume of solution of 100 cm^3 or above.

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>AO element</th><th>Guidance</th></tr>
<tr><td>35</td><td>(a)</td><td></td><td>Orange/brown to colourless ✓</td><td>1</td><td>1.1</td><td>IGNORE yellow</td></tr>
<tr><td>35</td><td>(b)</td><td></td><td>Contains a benzene ring ✓</td><td>1</td><td>1.1</td><td>ALLOW arene, IGNORE phenol NOT conjugated/delocalised ring/cyclic system without further qualification

Hydrocarbon is a CON</td></tr>
<tr><td>35</td><td>(c)</td><td></td><td>(neutral) iron(III) chloride/$FeCl_3$ AND (orange to) purple (AW) ✓</td><td>1</td><td>1.1</td><td>ALLOW iron(III) nitrate/$Fe(NO_3)_3$
if starting colour is given it must be orange or brown, any other colour is CON</td></tr>
<tr><td>35</td><td>(d)</td><td>(i)</td><td>
<table>
<tr><th></th><th>Reagent</th><th>Conditions</th><th>Colour change</th></tr>
<tr><td>Oxidation Alcohol</td><td>$Cr_2O_7^{2-}$/ H^+</td><td>Distil</td><td>Orange to green</td></tr>
<tr><td>Aldehyde or ketone</td><td>Tollen's/ Ammoniacal Ag^+

OR
Fehling's (A and B) / Benedict's
OR
$Cr_2O_7^{2-}$/ H^+</td><td>Warm

Heat

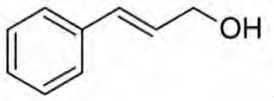
Heat under reflux</td><td>(Appearance of) Silver mirror (AW)

Blue → brick red

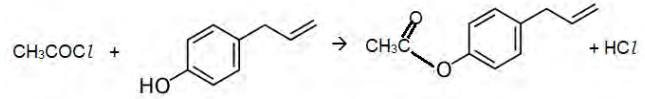
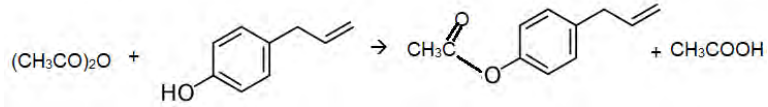
Orange → green</td></tr>
</table>
✓ ✓ ✓</td><td>3</td><td>1.2 x 3</td><td>1 mark per column of table correct
OR
if no complete column can score 1 for a fully correct row

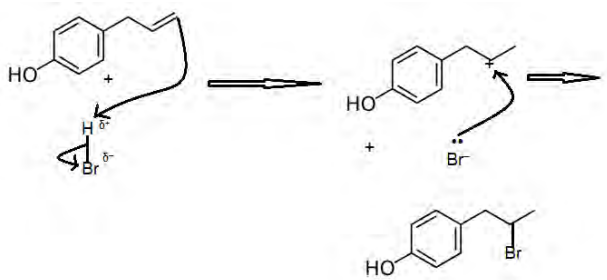
ALLOW acidified (potassium or sodium) dichromate as reagent in either or both tests. If another specific dichromate is identified it must be soluble. Formula must be correct.

In second row, if a silver salt is named it must be soluble.

For Fehling's solution or Benedict's solution ALLOW orange</td></tr>
<tr><td>35</td><td>(d)</td><td>(ii)</td><td> 

✓</td><td>1</td><td>1.1</td><td></td></tr>
<tr><td>35</td><td>(e)</td><td>(i)</td><td>H_2, Ni 'heat and pressure' (or specified sensible values) OR H_2, Pt, room temp ✓</td><td>1</td><td>1.1</td><td>ALLOW Ni/Pt as reagent or conditions
Any other reagent is a CON</td></tr>
</table>

Question			Answer	Mark	AO element	Guidance
35	(e)	(ii)	Use of ethanoyl chloride or ethanoic anhydride ✓ Rest of equation correct ✓  ✓ **OR**  ✓	**2**	**2.7 x 2**	If ethanoic acid is used **SCORE 0** **ALLOW** any unambiguous structures
35	(f)	(i)	**Reagents and conditions:** steam **AND** phosphoric acid (adsorbed onto silica) High T and P **OR** **Conc** sulfuric acid **followed by** water ✓ **Conditions:** Al_2O_3/alumina catalyst, heat. **OR** Conc sulfuric acid, (heat under) reflux **AND** **Product** (on equation) H_2O ✓	**1** **1**	**1.2 x 3**	If **conc** sulfuric acid is used in first reaction the water **MUST** clearly be added later to score mp1 Other reagents in either box is **CON** **IGNORE** pressure Check equation for product. State symbol not required but if given must be (l) or (g). (s) is **CON**

35	**(f)**	**(ii)**	The dehydration of the secondary alcohol could give the double bond either in the new position or the original position ✓ A mixture of products **(AW)** ✓	**2**	**3.2 x 2**	**IGNORE** references to position of equilibrium. Clear implication that both isomers would form is required for mp2
35	**(g)**	**(i)**	 Both curly arrows and partial charges on HBr ✓ Intermediate and attack of Br^- ✓	**2**	**1.2 x 2**	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. **ALLOW** R- for rest of structure Lone pair is not required on Br^- but if not present curly arrow must start at minus sign. Product is not required but if it is shown it must be correct for mp2 A valid mechanism leading to the anti Markownikov product **scores 1**
35	**(g)**	**(ii)**	H must add first (in either reaction) ✓ Product 1 cannot form as $H^{\delta+}$ as it is the only electrophile (**ORA**) ✓ Product 2 could form as Cl^- can react with the carbocation (once the $H^{\delta+}$ has reacted) ✓	**3**	**3.2 x 3**	Mp1 for clear implication of electrophilic reaction involving HBr Mp2 for identifying $H^{\delta+}$ as the only electrophile **OR** by stating that Br^- **AND** H_2O (**NOT** OH^-) are nucleophiles / not electrophiles. (**IGNORE** Cl^-) **IGNORE** comments comparing reactivity or steric factors in halide ions for mp3

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