# GCE

# Chemistry B

**H033/02:** Chemistry in depth

Advanced Subsidiary 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

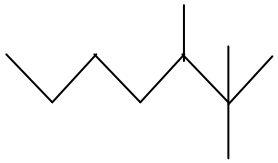
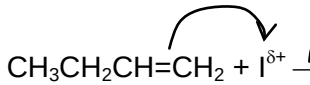
Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- 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.

| Question | | | Answer | Mark | AO element | Guidance |
|---|---|---|---|---|---|---|
| 1 | (a) | (i) | $C_{10}H_{22} \rightarrow C_4H_8 + C_6H_{14}$ ✓ | 1 | 1.2 | Molecular formulae of both products required |
| 1 | (a) | (ii) |  ✓ | 1 | 2.5 | **IGNORE** non-skeletal representation used as working and not rubbed out if a correct skeletal representation is present |
| 1 | (b) | | Collecting tube must be full of water ✓<br><br>(otherwise) gaseous products/gas will not collect in tube ✓<br><br>Bung is required to hold delivery tube in heated tube ✓<br><br>(otherwise) gaseous products/gas will escape (into atmosphere) ✓ | 4 | 3.3<br><br>3.4<br><br>3.3<br><br>3.4 | **ALLOW** answers drawn and/or written onto the diagram |
| 1 | (c) | | Propene ✓ | 1 | 2.1 | **ALLOW** propylene |
| 1 | (d) | | There is a lack of free rotation about the C=C ✓<br>The groups on each carbon atom (of the double bond) are different ✓ | 2 | 1.1 x 2 | **ALLOW** no rotation<br>**DO NOT ALLOW** 'movement' unless qualified by 'rotational'<br>**IGNORE** '*E/Z*' |
| 1 | (e) | |  <br>$CH_3CH_2CH{=}CH_2 + I^{\delta+}—Cl^{\delta-} \rightarrow CH_3CH_2C^+HCH_2I + Cl:^-$<br><br>  <br>$CH_3CH_2C^+HCH_2I + Cl:^- \rightarrow CH_3CH_2CHClCH_2I$<br>✓ for partial charges and curly arrow on ICl<br>✓ for full charges<br>✓ for other two curly arrows | 3 | 1.2 x 3 | Curly arrows should start (when projected back if necessary) on the relevant bond (or the minus charge or lone pair of $Cl^-$) and end (when projected forward if necessary) on the atom concerned or the bond about to be formed.<br><br>**ALLOW** $Cl:^-$ with or without lone pair in step 1 |

| Question | | | Answer | Mark | AO element | Guidance |
|---|---|---|---|---|---|---|
| 1 | (f) | | **FIRST CHECK THE ANSWER ON THE ANSWER LINE**<br>**If answer = 23.3 ($dm^3$) to 3 or more s.f. (23.2642 ...) award 4 marks**<br><br>$M_r$ of $C_8H_{18}$ = 114<br>n of $C_8H_{18}$ = (3.42/114) = 0.03 mol<br>n of $CO_2$ and $H_2O$ = (17 x 0.03) = 0.51 mol<br>(mark is for 0.51 – working not required) ✓<br><br>pV = nRT<br>V = nRT/p<br>(mark is for changing subject of equation – can be implied by substitution of numbers, even before T conversion) ✓<br><br>V = 0.51 x 8.314 x (550+273)/150000<br>(mark is for T conversion) ✓<br><br>V = 2.33 x $10^{-2}$ $m^3$<br>V = 23.3 $dm^3$<br>(mark is for V conversion from $m^3$ to $dm^3$) ✓ | 4 | **2.6**<br><br>**2.6**<br><br>**2.6**<br><br>**2.2** | **ALLOW** 2 or more sf<br>**ALLOW ECF** |
| 1 | (g) | (i) | Identity of compound:<br>Ethanol/$C_2H_5OH$/$CH_3CH_2OH$ ✓ | 1 | 3.1 | **ALLOW** displayed formula<br>**IGNORE** molecular formula of $C_2H_6O$ |
| | | (ii) | Evidence from mass spectrum:<br>Molecular ion peak at *m/z* = 46 **OR** $M_r$ = 46 ✓ | 1 | 3.2 | |
| | | (iii) | Evidence from IR spectrum:<br>O-H at 3350 ($cm^{-1}$) ✓ | 1 | 3.2 | Evidence from IR spectrum must include both bond and wavenumber<br>**ALLOW** reference to the range 3200 - 3600 |

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|---|---|---|---|---|---|---|
| **1** | ***(h)** | | *Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.*<br><br>**Level 3 (5-6 marks)**<br>Gives a balanced and <u>detailed</u> account of the adv **and** disadv of biofuels<br>*(<u>detailed means more than a simple statement)</u>*.<br><br>*There is a well-developed line of reasoning which is clear and logically structured.*<br><br>**Level 2 (3-4 marks)**<br>Gives a balanced account of the advantages and disadvantages of biofuels.<br>**OR**<br>Gives a detailed account of the advantages and outlines the disadvantages of biofuels, or vice versa.<br><br>*There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.*<br><br>**Level 1 (1-2 marks)**<br>Gives some of the advantages of biofuels.<br>**OR**<br>Gives some of the disadvantages of biofuels.<br><br>*There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant*.<br><br>**0 marks**<br>No response or no response worthy of credit. | **6** | **1.2 x 3**<br>**2.5 x 3** | *Indicative Scientific points include:*<br><br>**Advantages** *(compared with fossil fuels)*<br>• renewable<br>• the $CO_2$ they produce when burnt is the $CO_2$ the plants absorbed while growing/they are carbon neutral/less greenhouse gases/less global warming<br>• can be produced from waste (that would otherwise go to landfill)<br>• sustainable<br>• can be used as a straight replacement for diesel<br>• (biodiesel is) biodegradable (if spilled)<br>• (virtually) no sulfur/less $SO_2$/less acid rain<br>• less particulates/less damage to lungs<br>• less CO/less poisonous emissions<br>• less HC emissions/less photochemical smog/less respiratory problems<br>*(Ignore references to cost)*<br><br>**Disadvantages** *(compared with fossil fuels)*<br>• not a straight replacement for petrol/car engines need to be modified (to use fuels of high ethanol concentration)<br>• land used to grow crops for fuels can't be used to grow crops for food<br>• not carbon neutral as $CO_2$ is still produced when producing and transporting the fuel<br>• more $NO_x$<br>• ($NO_x$ causes, so) more tropospheric ozone/more respiratory problems<br>*(Ignore references to cost)* |

| Question | | | Answer | Mark | AO element | Guidance |
|---|---|---|---|---|---|---|
| 2 | (a) | | anode (+) $2Cl^- \rightarrow Cl_2 + 2e^-$ ✓<br>cathode (-) $2H_2O + 2e^- \rightarrow 2OH^- + H_2$ ✓ | 2 | 2.3 x 2 | **ALLOW** multiples or halves of equations<br>**ALLOW** $2Cl^- - 2e^- \rightarrow Cl_2$<br>**ALLOW** $2H^+ + 2e^- \rightarrow H_2$<br>**ALLOW** 'e' for '$e^-$'<br>**IGNORE** state symbols |
| 2 | (b) | (i) | It is the oxidation state/number of the chlorine/C*l* (in chloric(I) acid)/the OS/N of chlorine/C*l* is +1 ✓ | 1 | 1.2 | Both oxidation state and species required<br>If OS/N is given it must be +1 NOT 1+ |
| 2 | (b) | (ii) | It is easier to transport/store/handle/less toxic (ORA) ✓<br><br>because it is a solid and chlorine is a gas ✓ | 2 | 2.3 x 2 | The reason must be linked to the state and compared with the chlorine |
| 2 | (c) | (i) | **FIRST CHECK THE ANSWER ON THE ANSWER LINE**<br>**If answer = 2.48 x $10^{-5}$ (mol $dm^{-3}$) to 3 s.f. award 4 marks**<br><br>Amount $S_2O_3^{2-}$<br>= (12.4 / 1000 x 0.000100) = 1.24 x $10^{-6}$ (mol) ✓<br>Amount of $Cl_2$<br>= (1.24 x $10^{-6}$ / 2) = 6.20 x $10^{-7}$ (mol) ✓<br>Concentration of $Cl_2$<br>= (6.2 x $10^{-7}$ x 1000 / 25) = 2.48 x $10^{-5}$ (mol $dm^{-3}$) ✓<br><br>Appropriate number of s.f. = 3 ✓ | 4 | 2.4 x 4 | Award fourth mark independently for any number to 3sf that results from a shown calculation.<br><br>**ALLOW ECF** |

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|---|---|---|---|---|---|---|
| **2** | **(c)** | **(ii)** | **Any three from:**<br>(in 1) a 25 $cm^3$ measuring cylinder – use a measuring/graduated/volumetric pipette (instead) ✓<br><br>(in 2) rinse out a burette with de-ionised water – use the sodium thiosulfate/standard solution (instead) ✓<br><br>(in 3) record the initial burette reading to the nearest 0.1 $cm^3$ – should be to the nearest 0.05/±0.05 (instead) ✓<br><br>(in 5) add a few drops of starch indicator – (this should not be added before titrating –) add when addition of sodium thiosulfate has caused iodine/brown colour to become (pale) yellow/straw-coloured (instead) ✓ | **3** | **3.3x 2**<br>**3.4** | **ALLOW** just 'pipette' (in 1) |
| **2** | **(d)** | | Reducing agent: $SO_2$<br><br>Explanation: the oxidation state (number) of the sulfur/S (in $SO_2$) increases (goes) from +4 to +6 (in $SO_4^{2-}$) ✓ | **1** | **2.6** | **ALLOW** sulfur dioxide<br><br>**ALLOW** the oxidation state (number) of the bromine (Br) (in $Br_2$) decreases (goes) from 0 to -1 (in $Br^-$)<br>Both reducing agent and explanation required for mark |
| **2** | **(e)** | | (dark) red/brown liquid ✓ | **1** | **1.2** | **ALLOW** red/brown/orange but no other colour |
| **2** | **(f)** | **(i)** | cream(-coloured)/off-white precipitate/ppt/solid ✓ | **1** | **1.2** | **IGNORE** initial colours and changes of colour on standing<br>No other colour(s) should be mentioned |

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|---|---|---|---|---|---|---|
| **2** | **(f)** | **(ii)** | **FIRST CHECK THE ANSWER ON THE ANSWER LINE**<br>**If answer = rounds to 97(%) to 2 or more s.f. award 3 marks**<br><br>amount of $Br^-$ in 25.0 $cm^3$ sample<br>= (25.0 / 1000 x 0.0260) = 6.50 x $10^{-4}$ mol<br>amount of AgBr produced = 6.50 x $10^{-4}$ mol ✓<br><br>M(AgBr) = (107.9 + 79.9) = 187.8 g $mol^{-1}$<br>maximum mass of AgBr = (6.50 x $10^{-4}$ x 187.8)<br>= 0.122(07) (g) ✓<br><br>% yield = [(0.118 / 0.122) x 100] = 97% ✓ | **3** | **2.7 x 3** | **ALLOW** answer to 2 or more s.f. (96.7213...)<br>**ALLOW ECF** |

| Question | | | Answer | Mark | AO element | Guidance |
|---|---|---|---|---|---|---|
| 3 | (a) | | $^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{4}_{2}He$ ✓ | 1 | 2.6 | **ALLOW** atomic/mass numbers (only if correct) to be written to rhs of both H/He |
| 3 | (b) | | The student is correct AW (because)<br>The lines are in exactly the same positions/frequencies/ match up ✓<br><br>The energy transitions are the same ✓<br><br>Each element has unique energy levels **AW** ✓ | 3 | <br><br>3.1<br><br>3.2<br><br>3.2 | Must say 'student is correct' AW to score three marks.<br><br><br>**ALLOW** energy is quantized |
| 3 | (c) | | **FIRST CHECK THE ANSWER ON THE ANSWER LINE**<br>**If answer = % $^{113}$In = 4% $^{115}$In = 96% award 2 marks**<br><br>[112.90x] + [114.90(100-x)] / 100 = 114.82 ✓<br>112.90x + 11490 – 114.90x = 11482<br>-2x = -8<br>x = 4<br>% $^{113}$In = 4<br>% $^{115}$In = 96 ✓ | 2 | 2.6 x 2 | |
| 3 | (d) | (i) | $5p^1$ ✓ | 1 | 1.1 | |
| 3 | (d) | (ii) | Indium has/there are delocalised electrons ✓ | 1 | 1.1 | **IGNORE** it has metallic bonding |
| 3 | (d) | (iii) | Strong attraction between oppositely charged ions (in a giant structure) ✓ | 1 | 1.1 | **ALLOW** 'strong attractions in ionic bonding' |
| 3 | (e) | | (Student is incorrect about $InH_3$)<br>$InH_3$ has (only) 3 bond pairs (of electrons) ✓<br><br>(equal repulsion between b-p) gives trigonal planar shape/bond angles 120° ✓<br><br>$NH_3$ has 3 b-p and 1 l-p ✓ | 3 | <br>3.2<br><br>3.2<br><br>1.2 | |

| Question | | | Answer | Mark | AO element | Guidance |
|---|---|---|---|---|---|---|
| 4 | (a) | (i) | C–F is most polar ✓<br><br>(because) F is (the) most <u>electronegative</u> ✓ | 2 | 3.1<br><br>3.2 | **ALLOW** order of bond polarities C-F>C-C*l*>C-Br for MP1<br>**ALLOW** order of electronegativity F>C*l*>Br for MP2 |
| | (a) | (ii) | C–Br is broken ✓<br><br>(because the C–Br is the) <u>weakest bond</u> AW ✓ | 2 | 3.2 x 2 | <br><br>**ALLOW** order of bond enthalpies/strengths C-F>C-C*l*>C-Br for MP2 |
| 4 | (b) | | **FIRST CHECK THE ANSWER ON THE ANSWER LINE**<br>**If answer = $C_2Br_2F_4$ award 2 marks**<br><br>molar ratio of C:Br:F<br>9.2 / 12.0 : 61.5 / 79.9 : 29.3 / 19.0<br>0.77 0.77 1.54<br>1 : 1 : 2 **OR** empirical formula = $CBrF_2$ ✓<br><br>empirical mass = 129.9<br>$M_r$ = 259.8<br>(259.8 / 129.9) = 2<br>molecular formula = $C_2Br_2F_4$ ✓ | 2 | <br><br><br><br><br>2.4<br><br><br><br>2.8 | |
| 4 | (c) | | **FIRST CHECK THE ANSWER ON THE ANSWER LINE**<br>**If answer = (+) 346 (kJ $mol^{-1}$) (3 or more s.f.) award 3 marks**<br><br>Energy needed to break one C-Cl bond<br>(E = hν)<br>= 6.63 x $10^{-34}$ x 8.67 x $10^{14}$<br>= 5.75 x $10^{-19}$ (J) ✓<br><br>Energy needed to break one mole of C-Br bonds<br>= 5.75 x $10^{-19}$ x 6.02 x $10^{23}$<br>= 346042 (J) ✓<br>= (+) 346 kJ $mol^{-1}$ ✓ | 3 | 2.4 | The working for an incorrect answer **MUST** be checked in detail.<br><br>Do be aware that candidates may well multiply/divide the numbers in a different order (or even combine steps) to that shown in the answer column so the order of/the numbers in this method of working may not necessarily be seen. However, candidates should show evidence (explicit or implicit) of using E = hν (✓), and multiplying by both the Planck constant and the Avogadro constant (✓) and converting between J and kJ (✓). |

| Question | | | Answer | Mark | AO element | Guidance |
|---|---|---|---|---|---|---|
| 4 | *(d) | | *Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.*<br><br>**Level 3 (5-6 marks)**<br>Gives <u>details</u> of adv **and** disadv of $O_3$<br>*(<u>details</u> means correctly specifies tropos and stratos)*<br>**AND**<br>Describes the <u>catalytic</u> role of $NO_2$ in $O_3$ destruction supported by reference to equations<br>**AND**<br>Refers to $NO_2$ and $O_3$ reacting/forming photochemical smog in the tropos<br><br>*Well-developed reasoning, clear, logically structured.*<br><br>**Level 2 (3-4 marks)**<br>Gives the adv **and** disadv of $O_3$<br>**AND**<br>Describes the <u>catalytic</u> role of $NO_2$ in $O_3$ destruction supported by some reference to equation(s)<br><br>**OR**<br>Gives <u>details</u> of the adv **and** disadv of $O_3$<br>**AND**<br>Describes the disadv of $NO_2$ in the tropos and/or stratos.<br><br>*Reasoning with some structure. Information is relevant and supported by some evidence.*<br><br>**Level 1 (1-2 marks)**<br>Gives a reference to **either** the adv **or** disadv of $O_3$ | 6 | 1.2 (x4)<br>2.7 (x2) | *Indicative Scientific points include:*<br><br>**Ozone/$O_3$**<br>**Disadvantages**<br>In <u>troposphere</u><br>• it is toxic<br>• (it can lead to) photochemical smog/causes respiratory problems<br><br>**Advantages**<br>In <u>stratosphere</u><br>• it protects against/absorbs (harmful) ultraviolet radiation<br>*(relevant equation)*<br>$O_3$ -------> $O_2$ + O<br>• UV causes sunburn and skin cancer/DNA damage/ damages eyes/affects crops.<br><br>**Effect of nitrogen dioxide/$NO_2$ (on ozone)**<br>In <u>stratosphere</u>:<br>• It catalyses the breakdown of ozone<br>• it is split into radicals<br>*(relevant equation)*<br>$NO_2 + h\nu \rightarrow NO + O$<br>• (NO) radicals react with $O_3$<br>*(relevant equations)*<br>$NO + O_3 \rightarrow NO_2 + O_2$<br>$NO_2 + O \rightarrow NO + O_2$<br>$(O_3 + O \rightarrow 2O_2)$ overall<br>• radical(s) is/are regenerated/catalysts<br>In <u>troposphere:</u><br>• $NO_2$ reacts with $O_3$ to form photochemical smog |

| Question | | | Answer | Mark | AO element | Guidance |
|---|---|---|---|---|---|---|
| | | | **OR**<br>The disadv of $NO_2$ in the tropos and stratos<br>**OR**<br>A description of the catalytic role of $NO_2$ in ozone destruction.<br><br>*Attempt at logical structure/line of reasoning. Information is in the most part relevant*.<br><br>**0 marks**<br>No response or no response worthy of credit | | | |

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