

GCE

Chemistry B (Salters)

Unit **F335**: Chemistry by Design

Advanced GCE

Mark Scheme for June 2015

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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 used in scoris:

| Annotation | Meaning |
|-------------------|---|
| ✓ | correct response – there must be one tick for every one mark awarded |
| ✗ | incorrect response – These should not be used for every mark lost; just use them in places where it makes your marking clearer. |
| bod | benefit of the doubt given. Please give a tick as well |
| nbod | benefit of the doubt not given |
| ECF | error carried forward |
| ^ | information omitted |
| l | Ignored |
| SEEN | to be used on any other page where there is a response but no other annotation |
| BP | indicates a blank page that has been checked. |
| NGE | answer has some merit but doesn't quite score the mark |
| CON | contradicts a correct response and negates the mark |
| SF | to draw attention to the significant figures |

Subject-specific Marking Instructions that apply across the whole question paper to be included here.

Accept minor mis-spellings where the 'sound' is right (eg 'percipitate'), except:

- QWC mark
- where it changes a technical term (eg alkene/alkane)

If the answer on the answer line (or in box) differs from a previous answer (copying error), mark the answer on the answer line (or in box). If the answer line (or box) is blank, reward the answer elsewhere if possible.

In calculations, rounding errors should not be rewarded, unless the Mark Scheme indicates otherwise. Where a numerical answer is carried forward from a previous part, either the answer in the previous part or the answer left in the calculator may be used.

If it says 'mark separately' marks can be awarded even if the answer does not hang together well without the other mark. However, if the later marking point has words in brackets before it, the mark should only be awarded in the context of those words.

Formulae must have correct brackets and subscripts to score. Element symbols must have small second letters (eg not 'BA'). These errors and the use of a wrong symbol should, if possible, only result in the loss of ONE mark in a part (rather than more marks).

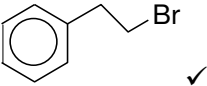
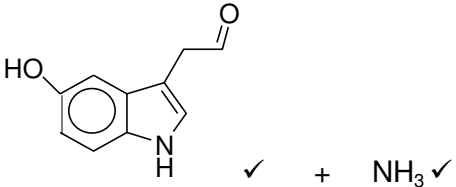
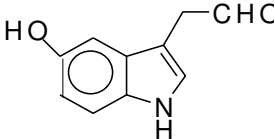
Multiples of equations are acceptable (including halves) unless specified otherwise.

Allow the omission of one plus sign in an equation if the species are still well separated.

MARK SCHEME

| Question | Answer | Mark | Guidance |
|----------|---|------|---|
| 1 a | CO ₂ covalent ✓ CaO <u>giant ionic</u> ✓ | 2 | IGNORE 'molecular', small molecules, etc but any suggestion of a giant structure is CON The words 'giant' and 'ionic' must be there, but other correct chemical words (eg 'lattice' can be ignored) If compounds are not identified, assume order of answers is that of question. |
| 1 b i | +161 | 1 | plus sign must be present |
| 1 b ii | $\Delta S_{\text{tot}} = 161 - 180000/298$ ✓ $= -443$ ✓ | 2 | <i>Award the following without consulting working:</i> 2 marks for -443 (to 3 or more sf) 1 mark for +160(.395...) (failure to multiply by 1000) 1 mark for +765 (not 765) (adding not subtracting) ALLOW ecf from 1bi NB Zone for (i) is shown above answer |
| 1 b iii | $T (= 180000/161) = 1118 \text{ K}$ ✓ (Temperature) above which/at which reaction is feasible ora AW OR temperature at which the system/reaction is at equilibrium ✓ | 2 | ALLOW ecf on 161 from 1(b)(i) and on non-use of 1000 from (b)(ii) (i.e. 1.1 K scores the first mark if (+)160 given in 1 (b)(ii)) IGNORE + sign. ALLOW 2 or more sig figs ALLOW 'spontaneous' or 'favourable' or 'viable' or 'occurs' etc for 'feasible' ALLOW $K_c = 1$ Mark separately NB the zones for (i) and (ii) are shown below answer. |
| 1 c i | calcium hydrogencarbonate ✓ | 1 | IGNORE gaps and capital letters ALLOW calcium(II) hydrogencarbonate NOT (calcium hydrogen) carbonate(IV) IGNORE 'bicarbonate' |
| 1 c ii | air/atmosphere ✓ | 1 | ALLOW 'dissolved in rainwater' (not just 'in rainwater') IGNORE 'from fossil fuels' etc |

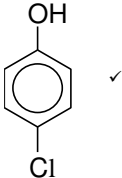
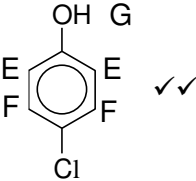
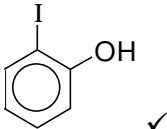
| Question | Answer | Mark | Guidance |
|----------|--|-----------|---|
| 1 c iii | CaCO ₃ is formed/ CaCO ₃ is limescale ✓ <u>Position of equilibrium</u> moves to left/towards reactants ✓ Gas/CO ₂ is released from solution AW ✓ | 3 | ALLOW water boils away/ is removed IGNORE references to endothermic reaction |
| 1 d | $\underline{\text{Ca}^{2+}(\text{g}) \quad (+) \quad \text{CO}_3^{2-}(\text{g}) \checkmark}$ $\underline{\text{CaCO}_3(\text{s}) \checkmark}$ $\text{Ca}^{2+}(\text{aq}) \quad (+) \quad \text{CO}_3^{2-}(\text{aq}) / \text{CaCO}_3(\text{aq}) \checkmark$ $\Delta H_{\text{hyd}} \text{CO}_3^{2-}(\text{aq}) = - (2800 + 12 - 1650) = -1162 \checkmark$ | 4 | ALLOW ecf on bottom line from wrong charges on top line IGNORE arrows between levels mark is for final answer (with sign) not working |
| | Total | 16 | |

| Question | Answer | Mark | Guidance |
|----------|---|------|---|
| 2 a i | $C_8H_{12}N_2$ ✓ | 1 | ALLOW elements in any order |
| 2 a ii | 109° ✓ four pairs/groups/sets of electrons/ four areas of electron density (around N) ✓ repel and get as far away from each other as possible/ minimise repulsion ✓ | 3 | ALLOW 106 – 110° ALLOW three bonding pairs and one lone pair 3rd point must be in terms of electrons repelling IGNORE bonds repelling IGNORE '(repel) as much as possible' Mark separately |
| 2 b |  ✓ | 1 | must be a skeletal formula |
| 2 c | Benzene/ A undergoes substitution (more easily than addition) ✓ mention of delocalised electrons (in A) ✓ Benzene/ A does not undergo addition (readily) ✓ because it has no double bonds/alkene ✓ OR B undergoes addition ✓ because it has double bonds/alkene ✓ | 4 | IGNORE references to mechanism or products IGNORE references to stability or bond length QWC (in second set of two marks) only award addition mark if mention of double bonds. Addition must be mentioned not just implied |
| 2 d |  ✓ + NH ₃ ✓ | 2 | ALLOW  or any correct structural formula including mixtures of structural and skeletal |

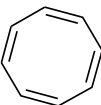
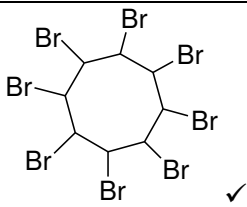
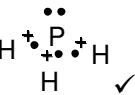
| | Answer | Mark | Guidance |
|-----|--|------|--|
| 2 e | <p>1. (substrate is) serotonin ✓</p> <p>2. moclobemide/inhibitor binds with <u>active/receptor site</u> AW ✓</p> <p>3. (moclobemide) blocks (the <u>active/receptor site</u>) OR (moclobemide) competes with <u>the substrate</u> OR <u>substrate</u> cannot bind (as well) / enzyme-<u>substrate</u> complex cannot form (as well) ✓ OR fewer/less active sites available for <u>substrate</u></p> <p>4. (increased serotonin/substrate concentration allows) increased rate ✓</p> | 4 | <p>ALLOW '(CH₂)NH₂ group of serotonin'</p> <p>ALLOW 'bonds', 'fits', 'forms complex' instead of 'binds' in 2.</p> <p>ALLOW 'serotonin' for substrate or ecf on substrate name from 1.</p> <p>IGNORE moclobemide reacting with substrate</p> <p>IGNORE reasons</p> |
| 2 f | <p>1. <u>electrons</u> move up(AW) <u>energy levels</u> ✓</p> <p>2. light/ radiation is absorbed (with frequency related to energy gap by) $\Delta E = hv/hf$ ✓</p> <p>3. complementary colour/frequency... OR colours/frequencies not absorbed... ...are <u>reflected/ transmitted</u> ✓</p> <p>4. phenelzine has small(er) chromophore/less delocalisation (therefore) larger ΔE/energy gap/v/frequency (ora for coloured/'aromatic' molecules) ✓</p> <p>5. uv has higher frequency/ higher energy (than visible light) ora ✓</p> | 5 | <p>reference to d electrons is CON to this mark only</p> <p>IGNORE 'E=hv' unless 'energy gap/difference' mentioned in close proximity</p> <p>ALLOW 'frequency proportional to energy gap' accept the two parts of 2. if they are separated in the answer.</p> <p>ALLOW 'complimentary'</p> <p>Any reference to electrons falling and giving out/emitting light CONs 3.</p> <p>4. may be split through answer</p> <p>This can be scored if a reference to phenelzine absorbing in uv immediately follows the second part of 4. ('larger ΔE/energy gap/v/frequency')</p> |
| | | 20 | |

| Question | Answer | Mark | Guidance |
|----------|--|------|---|
| 3 a i | propene ✓ | 1 | NOT prop-1-ene |
| 3 a ii | similarity: C-C bond formed/ C atom attached to benzene OR alkylation OR hydrocarbon (chain)(AW) attached/substituted/added ✓ difference: no use of halogen compound OR only one product/ no HCl (or H ⁺) formed/lost ✓ | 2 | IGNORE references to alkenes as reactants ALLOW 'eliminated' |
| 3 b i | 1. more/greater/higher yield OR more/greater amount of compound B /product ✓ 2. fewer molecules/particles/moles on right-hand side/product <i>ora</i> ✓ 3. molecules/particles.... in smaller volume/space (not area) OR ...closer together OR ...more concentrated AW ✓ 4. greater frequency of collisions AND faster rate (of reaction) AW ✓ | 4 | IGNORE 'equilibrium moves to the right' unless it indicates which side has fewer moles QWC marking point 1 depends on marking point 2 being scored 'molecules have increased energy' CONs this point marking points 3 and 4 can be marked separately 4. frequency must be implied (not just 'more collisions') IGNORE 'chance of collision' |
| 3 b ii | (Forward) reaction exothermic (<i>ora</i>) AND equilibrium constant smaller AW ✓ Rate (too) slow(er)/takes too long to reach equm below 250 AW ✓ | 2 | IGNORE 'equilibrium moves to the left' but 'equilibrium moves to left (AW) in endothermic direction' will score first part of marking point. IGNORE 'compromise' |
| 3 b iii | 100% ✓ no waste (product) (to be disposed of) ✓ | 2 | IGNORE 'high' IGNORE reference to toxic/harmful NOT 'no by-product' |

| Question | Answer | Mark | Guidance |
|----------|--|------|---|
| 3 c i | 2-hydroxy-2-methylpropan(e)nitrile / (propanone) cyan(o)hydrin ✓ HCN/KCN/NaCN ✓ | 2 | IGNORE dashes, commas and spaces ALLOW: • 'hydroxy' and 'methyl' reversed; • 2-cyanopropan-2-ol; • 2-methylpropan-2-olnitrile; • 2-cyano-2-hydroxypropane NOT a mixture of names with 'cyanhydrin' ALLOW CN ⁻ and names |
| 3 c ii | alkene / carbon to carbon double bond ✓ (primary) amide ✓ | 2 | IGNORE 'C=C' 'secondary' is CON |
| 3 c iii | methanol / CH ₃ OH ✓ | 1 | |
| 3 c iv | addition (polymerisation) since C=C / carbon-carbon double bond/alkene double bond/unsaturated ✓ <pre> H H-C-H H -C-C- H C=O O H-C-H H ✓ </pre> | 2 | both points needed to score first mark ALLOW 'CH ₃ ' groups not displayed, but everything else must be full structural IGNORE brackets and 'n' |
| 3 d i | electrophilic substitution ✓ | 1 | |
| 3 d ii | C ₆ H ₅ OCl ✓ | 1 | ALLOW atoms in any order |
| 3 d iii | 3 ✓ | 1 | |
| 3 e i | three proton/H/hydrogen <u>environments</u> | 1 | IGNORE 'H ⁺ ' |

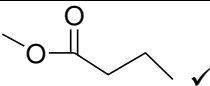
| Question | Answer | Mark | Guidance |
|----------|---|------|--|
| e ii |  | 1 | ALLOW hydrogen atoms shown on ring (for part (iii)) |
| e iii |  <p>one mark for labelling G one mark for labelling E and F (which can be reversed)</p> | 2 | If e(ii) is an incorrect isomer, award one mark for G if it labels the OH hydrogen E and F must be indicated on both sides to score second mark. |
| e iv | <p>Protons are attached to a carbon atom where... OR the proton environment has... ...the adjacent carbon with one proton ✓</p> | 1 | must imply 'adjacent' eg 'neighbouring' etc and mention both carbons (unless 'proton environment' replaces the first carbon) and both protons. ALLOW hydrogen/H (not H ⁺) for 'proton' |
| 3 f |  <p>I-Cl polarised since electronegativity difference AW ✓ I / I⁺ / I^{δ+}is the electrophile/ is attracted to delocalised electrons/ is attracted to electron density ✓</p> | 3 | ALLOW formula of any iodophenol but must be monosubstituted NOT hydrogens on the ring here 'addition' is CON |
| | | 29 | |


| Question | Answer | Mark | Guidance |
|----------|---|------|---|
| 4 a | $\text{CaO} + 3\text{C} \rightarrow \text{CO} + \text{CaC}_2$ OR $2\text{CaO} + 5\text{C} \rightarrow \text{CO}_2 + 2\text{CaC}_2$ ✓ | 1 | IGNORE state symbols |
| 4 b i | $\text{CaCN}_2 + 3\text{H}_2\text{O} \rightarrow \text{CaCO}_3 + 2\text{NH}_3$ ✓✓ | 2 | <i>For one mark:</i> <ul style="list-style-type: none"> • correct substances but unbalanced equation • the correct balanced equation with an error (eg $\text{Ca}(\text{CO}_3)$) • $\text{CaCN}_2 + 3\text{H}_2\text{O} \rightarrow \text{CaO} + \text{CO}_2 + 2\text{NH}_3$ • $\text{CaCN}_2 + 4\text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2 + \text{CO}_2 + 2\text{NH}_3$ |
| 4 b ii | (nitrogen is unreactive/inert) (nitrogen) has a (strong) triple bond (o$\text{E} \text{N} \text{N}$) ✓ OR high (AW) (activation) energy/enthalpy... ... to break bond | 1 | |
| 4 b iii | nitrogen <u>compounds</u> are needed (by plants) for: growth/ making protein/ making amino acids/DNA ✓ | 1 | ALLOW for 'nitrogen compounds': named (appropriate) nitrogen compounds or 'nitrates' or 'ammonium ions' (or formulae) IGNORE references to fertilisers |
| 4 b iv | $(28 \times 100 / 80.1 =) 35.0 \%$ ✓ to 3sf ✓ | 2 | Any answer that rounds to 35 scores first mark Second mark is for correct answer to 3sf i.e. 35.0 |
| 4 c i | -3 +2 ✓ | 1 | signs must precede numbers |
| 4 c ii | nitrogen monoxide ✓ | 1 | ALLOW nitrogen(II) oxide (allow gaps), NOT nitrogen(II) monoxide no ecf from (c)(i) |
| 4 c iii | $(50-4x) + (50-5x) + 4x + 6x = 105$ $x = 5$ $\% \text{ conversion} = (20 \times 100/50) = 40\%$ ✓✓ | 2 | 40% on answer line scores 2 marks without reference to working. ALLOW , for 1 mark, one of: <ul style="list-style-type: none"> • $(50-4x) + (50-5x) + 4x + 6x = 105$ • $(50-x) + (50-1.25x) + x + 1.5x = 105$ • 20 cm^3 of NH_3 reacted OR 30 cm^3 of NH_3 left |

| Question | Answer | Mark | Guidance |
|----------|--|------|--|
| 4 c iv | NO is <u>oxidised by oxygen</u> / <u>reacts with oxygen</u> to form NO ₂ ✓ NO ₂ is brown ✓ | 2 | ALLOW 'it' for 'NO' |
| 4 d i | 180° ✓ H-C≡C-H ✓ | 2 | Structure mark can be awarded if not linear Angle mark depends on: <ul style="list-style-type: none"> • correct structure being given. • structure being linear • curve indicating the angle starting and finishing on bonds rather than an atom <i>Give benefit of doubt on rubbed out structures where possible (also in following parts)</i> |
| 4 d ii |  ring of eight carbons ✓ correct double bonds ✓ | 2 | If a correct non-skeletal structural formula is given, award one mark only. Do not award either mark if there are any extra carbons on ring. Second mark depends on first. |
| 4 d iii |  ✓ | 1 | must be skeletal to score |
| 4 e i | Ca ₃ P ₂ ✓ | 1 | |
| 4 e ii |  ✓ | 1 | |

| Question | Answer | Mark | Guidance |
|----------|--|------|--|
| 4 e iii | <p>1. ammonia/NH₃ (not just N) forms hydrogen bonds with/in <u>water</u> ✓</p> <p>2. phosphane/PH₃ (not just P) forms id-id bonds with/in <u>water</u> ✓</p> <p>3. P is less electronegative (than N) ora ✓</p> <p>4. <i>consideration of relative energies</i> more energy is needed to break the hydrogen bonds in water than is released/made by making the imb/named imb (between phosphane and water) OR hydrogen bonds in water are stronger than imb/named imb (between phosphane and water)</p> <p>OR similar energy is needed to break the hydrogen bonds in water than is released/made by forming the hydrogen bonds (between) ammonia (and water) OR hydrogen bonds in water are of similar strength(AW) to those (between) ammonia (and water). ✓</p> | 4 | <p>ALLOW forms no/weaker hydrogen bonds OR forms permanent dipole-permanent dipole bonds/ forms Van der Waals ALLOW abbreviations/spelling errors and 'forces' for 'bonds'</p> <p>IGNORE 'more energy is needed to break the hydrogen bonds in water than is <i>needed</i> to break the imb' etc</p> <p>'in water' must be stated or implied</p> <p>IGNORE reference to number of bonds broken and made</p> <p>ALLOW statements that suggest that the hydrogen bonding in water is weaker than that between ammonia and water</p> |
| | | 24 | |

| Question | Answer | Mark | Guidance |
|----------|---|------|---|
| 5 a | methylpropanoic acid / 2-methylpropanoic acid ✓ | 1 | IGNORE gaps and dashes |
| 5 b i | <pre> H O H H H H-C-O-C-C-C-C-H H H H H H H H H-C-O-C-C-C-C-H H O H H H H H H H-C-O-C-C-C-C-H H O H H H </pre> <p>backbone and ester groups displayed ✓ C₃H₇ groups displayed ✓</p> | 2 | ester groups wrong way round scores zero |
| 5 b ii | No carbon-carbon double bonds/ No C=C OR all C-C bonds are single ✓ | 1 | Not just 'double bonds' for 'C=C' |
| 5 c i | $C_4H_8O_2 (aq) \rightleftharpoons C_4H_7O_2^- (aq) + H^+ (aq)$ ✓ | 1 | State symbols required ALLOW $H_2O + C_4H_8O_2 \rightleftharpoons C_4H_7O_2^- + H_3O^+$ ALLOW $C_3H_7COO^-$ or $C_3H_7CO_2^-$ for $C_4H_7O_2^-$ |
| 5 c ii | Weak acid/ incompletely ionised/ incompletely dissociated ✓ | 1 | |
| 5 c iii | No/not enough... H ⁺ / H ₃ O ⁺ ions/ protons ✓ (H ⁺) react (with carbonate) ✓ | 2 | ALLOW 'needs water to ionise' for first mark Second mark depends on first |

| Question | Answer | Mark | Guidance |
|----------|---|------|---|
| 5 c iv | <p>1. (added) H^+/acid... ...reacts with (AW) $C_4H_7O_2^-$ ORmoves equilibrium to left and forms acid✓</p> <p>2. (added) OH^- /alkali/ (sodium)hydroxide... ...reacts with (AW) $C_4H_8O_2/H^+$ ORmoves equilibrium to right to replace H^+/ butanoic acid dissociates/ionises✓</p> <p>3. $C_4H_7O_2^-$ (concentration) and $C_4H_8O_2$ (concentration) large/ reservoir/ in excess AW ✓</p> <p>4. pH does not change (much) ✓</p> | 4 | <p>ALLOW A^- or 'salt' or 'anion' or 'butanoate' or '(conjugate) base' or ecf from(c)(i)* for $C_4H_7O_2^-$ throughout ALLOW HA or '(butanoic) acid' or ecf from(c)(i)* for $C_4H_8O_2$ throughout IGNORE 'base' for 'alkali' (added)</p> <p>References to large amounts/reserves of H^+ or OH^- are CON</p> <p>*NB the zone for 5(c)(i) is given below the answer if needed.</p> |
| 5 d i | <p>$[H^+] = (\sqrt{(1.51 \times 10^{-5} \times 0.02)}) = 5.5(0) \times 10^{-4}$ ✓ pH = 3.26 ✓</p> | 2 | <p>Any pH value rounding to 3.3 scores 2 ALLOW ecf for second mark if $[H^+] < 0.02$ To score either mark alone, first mark must include '$[H^+] =$' or '$H^+ =$'</p> |
| 5 d ii | <p>1. calculation of $[OH^-]$ $[OH^-] = 5 \times 0.02/55 = 1.82 \times 10^{-3}$ ✓</p> <p>2. calculation of $[H^+]$ from $[OH^-]$ $[H^+] = 1 \times 10^{-14}/$ 'calculated $[OH^-]$' eg $1 \times 10^{-14}/ 1.82 \times 10^{-3} = 5.49 \times 10^{-12}$ ✓</p> <p>3. calculation of pH from $[H^+]$ pH = 11.3 ✓</p> | 3 | <p><i>Allow the following answers (to 1dp) without reference to working:</i> 3 marks: 11.3 2 marks: 12.0 (just dilution of NaOH) 2 marks: 12.3 (pH of 0.02M NaOH) Either working or values score first two marks ALLOW ecf for second mark provided '$[OH^-]/OH^- =$' shown ALLOW ecf for third mark if '$[H^+]/H^+ =$' shown and value is $< 1 \times 10^{-10}$</p> |
| 5 e i |  | 1 | <p>OR other way round bond angles can vary</p> |

| Question | Answer | Mark | Guidance |
|----------|---|------|---|
| 5 e ii | $\text{CH}_3\text{CH}_2\text{CH}_2\text{COCl}$ ✓ | 1 | ALLOW any correct structural or skeletal formula or mixture IGNORE $\text{C}_3\text{H}_7\text{COCl}$ (chain could be branched) |
| 5 e iii | permanent (dipole)–permanent dipole AND instantaneous (dipole)–induced dipole ✓ acid has hydrogen bonding ✓ more <u>energy</u> required to separate particles/break bonds in acid (ora) so ester has lower bpt (ora) ✓ | 3 | type of imb must not be abbreviated or mis-spelled (QWC) 'hydrogen bonding' CONS first mark |
| 5 f i | $\cdot\ddot{\text{O}}\text{H}$ ✓ unpaired electron ✓ | 2 | IGNORE 'lone', 'single', 'unbonded' Mark separately |
| 5 f ii |  ✓ | 1 | arrows must be 'half-arrows' and (when projected) start on bond and end on atoms |
| 5 f iii | homolytic (fission) ✓ | 1 | ALLOW homolysis |
| 5 f iv | only 5.4 initiation ✓ rest propagation ✓ | 2 | mark separately |
| 5 f v | $\text{O}_2 + \text{R-CH}_2\text{-CH}_2\text{-} \rightarrow \text{R-CH(OOH)-CH}_2\text{-}$ ✓ | 1 | ALLOW $\text{R-C(OOH)H-CH}_2\text{-}$ but end bonds must be there |

| Question | Answer | Mark | Guidance |
|----------|---|------|--|
| 5 f vi | aldehyde ✓ ((conc) sulfuric/hydrochloric) acid AND (potassium/sodium) dichromate AND heat/warm/reflux/distil AND green/ blue ✓ | 2 | ALLOW alkanal IGNORE carbonyl ALLOW formulae instead of names for second mark, but IGNORE incorrect formulae if correct names given IGNORE oxidation state of dichromate IGNORE 'orange' but any other starting colour is CON ALLOW: <ul style="list-style-type: none"> • 'silver nitrate and ammonia'/Tollens reagent and 'black ppt /silver' • Fehling's/ Benedict's reagent and 'red ppt' • 'acid permanganate' (names or formulae) and 'colourless' no ecf from first mark and second mark depends on first being scored. |
| | | 31 | |

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