Pearson Edexcel

# Mark Scheme (Results)

## October 2022

Pearson Edexcel International Advanced Subsidiary Level
In Chemistry (WCH12)
Paper 01: Energetics, Group Chemistry, Halogenoalkanes and Alcohols

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## General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

## Using the mark scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:

- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit. ( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer. ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

**Section A**

| Question Number | Answer | Mark |
|---|---|---|
| 1 | **The only correct answer is B** (463.5)<br><br>***A*** *is not correct because 242 has been subtracted not added*<br>***C*** *is not correct because 498 has not been divided by 2*<br>***D*** *is not correct because the final answer has not been divided by 2* | 1 |

| Question Number | Answer | Mark |
|---|---|---|
| 2 | **The only correct answer is A** ($Na(s) + ½Cl_2(g) \rightarrow NaCl(s)$)<br><br>***B*** *is not correct because the enthalpy change of formation refers to only one mole of a compound*<br>***C*** *is not correct because the Na should be solid and the Cl should be* $½Cl_2$<br>***D*** *is not correct because ions are not involved in the enthalpy change of formation* | 1 |

| Question Number | Answer | Mark |
|---|---|---|
| 3 | **The only correct answer is D** ($-193\ kJ\ mol^{-1}$)<br><br>***A*** *is not correct because 4 ×* $H_2$ *has been used, not 2 and the sign is incorrect*<br>***B*** *is not correct because 4 ×* $H_2$ *has been used, not 2*<br>***C*** *is not correct because the sign is incorrect* | 1 |

| Question Number | Answer | Mark |
|---|---|---|
| **4** | **The only correct answer is C** (0.72 g)<br><br>***A*** *is not correct because a 2:1 ratio has been used, not 1:2*<br>***B*** *is not correct because a 1:1 ratio has been used, not 1:2*<br>***D*** *is not correct because a 1:3 ratio has been used, not 1:2* | **1** |

| Question Number | Answer | Mark |
|---|---|---|
| **5** | **The only correct answer is C** (solubility of the sulfates)<br><br>***A*** *is not correct because the reactivity of the elements increases down the group*<br>***B*** *is not correct because the solubility of the hydroxides increases down the group*<br>***D*** *is not correct because the thermal stability of the carbonates increases down the group* | **1** |

| Question Number | Answer | Mark |
|---|---|---|
| **6** | **The only correct answer is C** (4)<br><br>***A*** *is not correct because there are 4 isomers*<br>***B*** *is not correct because there are 4 isomers*<br>***D*** *is not correct because there are 4 isomers* | **1** |

| Question Number | Answer | Mark |
| --- | --- | --- |
| 7 | **The only correct answer is D** (nucleophilic substitution)<br><br>***A*** *is not correct because the $CN^-$ ion is a nucleophile and the reaction is a substitution*<br>***B*** *is not correct because the reaction is a substitution*<br>***C*** *is not correct because the $CN^-$ ion is a nucleophile* | **1** |

| Question Number | Answer | Mark |
| --- | --- | --- |
| 8 | **The only correct answer is D** (energy emitted, from excited state to ground state)<br><br>***A*** *is not correct because the flame colour is not caused by the absorption of energy*<br>***B*** *is not correct because electrons do not emit energy on promotion*<br>***C*** *is not correct because electrons do not absorb energy on returning to the ground state* | **1** |

| Question Number | Answer | Mark |
| --- | --- | --- |
| 9 | **The only correct answer is A** (hydrogen iodide has stronger London forces than hydrogen bromide)<br><br>***B*** *is not correct because hydrogen iodide has a smaller permanent dipole than hydrogen bromide*<br>***C*** *is not correct because neither HBr or HI can form hydrogen bonds*<br>***D*** *is not correct because the H–I bond is weaker than the H–Br bond* | **1** |

| Question Number | Answer | Mark |
|---|---|---|
| 10 | **The only correct answer is B** ($NaNO_3$)<br><br>***A*** *is not correct because both oxygen and nitrogen dioxide would be produced*<br>***C*** *is not correct because both oxygen and nitrogen dioxide would be produced*<br>***D*** *is not correct because both oxygen and nitrogen dioxide would be produced* | **1** |

| Question Number | Answer | Mark |
|---|---|---|
| 11 | **The only correct answer is B** (  )<br><br>***A*** *is not correct because propan-2-ol has a lower boiling temperature as the alcohol is branched*<br>***C*** *is not correct because butane has a lower boiling temperature as it does not form hydrogen bonds*<br>***D*** *is not correct because 2-methylpropane has a lower boiling temperature as it does not form hydrogen bonds* | **1** |

| Question Number | Answer | Mark |
|---|---|---|
| 12 | **The only correct answer is A** (HCl)<br><br>***B*** *is not correct because hydrogen bonds form between molecules of* $H_2O$<br>***C*** *is not correct because hydrogen bonds form between molecules of HF*<br>***D*** *is not correct because hydrogen bonds form between molecules of* $NH_3$ | **1** |

| Question Number | Answer | Mark |
|---|---|---|
| 13 | **The only correct answer is C** (+5)<br><br>***A*** *is not correct because the oxidation number is +5 in* $BrO_3^-$<br>***B*** *is not correct because the oxidation number is +5 in* $BrO_3^-$<br>***D*** *is not correct because the oxidation number is +5 in* $BrO_3^-$ | **1** |

| Question Number | Answer | Mark |
|---|---|---|
| 14 | **The only correct answer is D** ($Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$)<br><br>***A*** *is not correct because Cl has undergone disproportionation*<br>***B*** *is not correct because O has undergone disproportionation*<br>***C*** *is not correct because Cl has undergone disproportionation* | **1** |

| Question Number | Answer | Mark |
|---|---|---|
| 15 | **The only correct answer is D** (reactivity of the elements increases)<br><br>***A*** *is not correct because atomic radius increases down the group*<br>***B*** *is not correct because the boiling temperature increases down the group*<br>***C*** *is not correct because electronegativity decreases down the group* | **1** |

| Question Number | Answer | Mark |
|---|---|---|
| 16 | **The only correct answer is A** (0.75)<br><br>***B*** *is not correct because this is the reciprocal of the correct answer*<br>***C*** *is not correct because this is the total volume at 40 seconds divided by 40*<br>***D*** *is not correct because this is the initial rate* | **1** |

| Question Number | Answer | Mark |
|---|---|---|
| 17(a) | **The only correct answer is C (**the area under the curve to the right of the activation energy, $E_a$ represents the number of particles with enough energy to react)<br><br>***A*** *is not correct because this is the mode energy of the particles*<br>***B*** *is not correct because the activation energy is the minimum energy required for a reaction to take place*<br>***D*** *is not correct because a catalyst would move the activation energy to the left* | **1** |

| Question Number | Answer | Mark |
|---|---|---|
| 17(b) | **The only correct answer is D** (shifts to the left, higher)<br><br>***A*** *is not correct because the curve would shift to the left and the peak would be higher*<br>***B*** *is not correct because the curve would shift to the left*<br>***C*** *is not correct because the peak would be higher* | **1** |

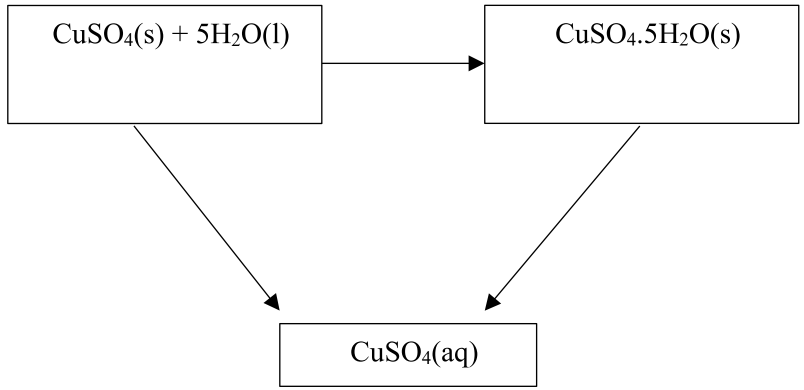
| Question Number | Answer | Mark |
|---|---|---|
| 18 | **The only correct answer is C** (arrow 3)<br><br>***A*** *is not correct because the arrow 1 is correctly used*<br>***B*** *is not correct because the arrow 2 is correctly used*<br>***D*** *is not correct because the arrow 4 is correctly used* | **1** |

| Question Number | Answer | Mark |
|---|---|---|
| 19 | **The only correct answer is B** (yellow to orange and pink to colourless)<br><br>***A*** *is not correct because the phenolphthalein colour change is reversed and the methyl orange colour change is for acid to neutral*<br>***C*** *is not correct because the methyl orange colour change is for acid to neutral*<br>***D*** *is not correct because the phenolphthalein colour change is reversed* | 1 |

**Total for Section A = 20 Marks**

**Section B**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **20(a)** | • M1 moles of $CuSO_4.5H_2O$ **(1)**<br>• M2 energy change **(1)**<br>• M3 enthalpy change per mole **(1)**<br>• M4 correct sign **and** units **and** 2 or 3 SF **(1)**<br><br>Note M4 is not a stand-alone mark it depends on a sensible calculation by dividing joules by a number of moles. | <u>Example of calculation:</u><br><br>10.68 ÷ 249.6 = 0.042788/ 89÷2080<br><br>2.5 × 55 × 3.70 = 508.75 (J) = 0.50875 (kJ)<br><br>508.75 ÷ 0.042788 = 11890 (J $mol^{-1}$)<br>Or<br>0.50875 ÷ 0.042788 = 11.890 (kJ $mol^{-1}$)<br><br>(+)11900 J $mol^{-1}$ / (+)11.9 kJ $mol^{-1}$ / (+)12000 J $mol^{-1}$ / (+)12 kJ $mol^{-1}$<br><br>TE throughout<br><br>Correct answer with sign and units and 2-3 SF score (4) | **4** |

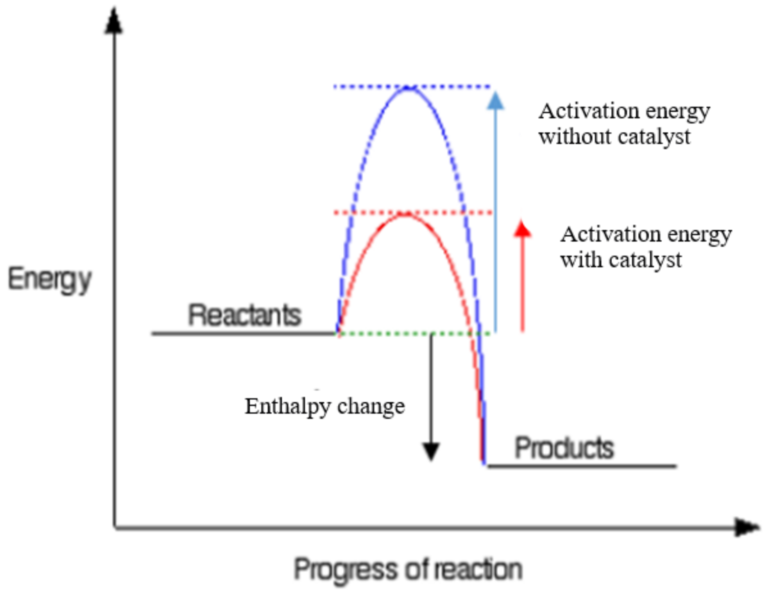
| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **20(b)(i)** | A diagram which shows<br>• both arrows pointing down **(1)**<br>• correct product in box **(1)** | Example of diagram<br><br>Ignore any extra water in the box e.g. + $5H_2O$<br><br>Ignore any numbers on the arrows<br>Allow ions separated $Cu^{2+}$ (aq) and $SO_4^{2-}$ (aq)<br>Allow $CuSO_4$ + (aq) | **2** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **20(b)(ii)** | • correct use of data **(1)**<br><br>• correct sign and answer **(1)**<br><br>Note the only TE is using their value from (a). | Example of calculation:<br><br>(+) – 67.4 (kJ $mol^{-1}$) (–) +11.9 (kJ $mol^{-1}$)<br><br>–79.3 / –79 (kJ $mol^{-1}$)<br>Ignore units unless wrong but not award mixed units<br><br>Allow –79.16(kJ $mol^{-1}$) for rounding moles to 0.43<br>Allow TE on value from (a).<br><br>No TE on incorrect cycle<br>Ignore SF | **2** |

**Total for Question 20 = 8 Marks**

| Question Number | Answer | Additional Guidance | Mark |
| --- | --- | --- | --- |
| **21(a)(i)** | An answer that makes reference to the following points:<br><br>• **both** have London forces (only) **(1)**<br><br>• S molecules have more electrons / S is a larger molecule (than oxygen) / S electrons are more easily polarised **(1)**<br><br>Independent marks | Accept dispersion forces<br>Accept instantaneous dipole-induced dipoles<br>Allow van der Waals' forces<br><br>Note any mention of other intermolecular forces being present e.g. dipole-dipole negates M1<br><br>Allow $S_8$, rather than $O_2$<br>Allow just S has more electrons<br>Allow just S is larger<br>Allow reverse argument<br>Ignore electron density<br>Do not award a S atom has more electrons than an oxygen molecule | |

| Question Number | Answer | | Additional Guidance | Mark |
|---|---|---|---|---|
| 21(a)(ii) | An answer that makes reference to the following points:<br><br>Increasing temperature | | | 4 |
| | • equilibrium shifts to the LHS/backwards | **(1)** | Ignore any reference to yield | |
| | • in the endothermic direction (in order to reduce the temperature) | **(1)** | Allow reaction is exothermic<br>Allow favours endothermic direction | |
| | Increasing pressure | | | |
| | • equilibrium shifts to the RHS/forward | **(1)** | Allow favours RHS/forward direction | |
| | • to the side with fewer (gaseous) molecules/moles (in order to reduce the pressure) | **(1)** | Allow 3 moles (of gas ) on the LHS (forms) 2 moles(of gas) on the RHS. If numbers of moles are quoted they must be correct.<br>Allow reverse argument<br>Ignore any reference to rate | |
| | Independent marks | | | |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| 21(a)(iii) | • reactants/(2)$SO_2$ + $O_2$ higher than products/(2)$SO_3$ **(1)**<br>• non-catalysed activation energy correctly labelled and arrow going up **(1)**<br>• catalysed activation energy correctly labelled and arrow going up **(1)**<br>• enthalpy change labelled and arrow going down **(1)**<br><br>If just one curve is drawn max (3)<br><br>MB distribution scores (0)<br><br>If endothermic reaction TE available for M2, M3 and M4<br><br>Double-headed arrows or no arrow heads penalise once | <br><br>Allow energy for enthalpy<br>Allow $E_a$ and $E_{cat}$<br>Allow intermediates in the activation energy curves<br>Ignore sign and units of energy even if incorrect | 4 |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **21(a)(iv)** | An explanation that makes reference to the following points:<br>• (operates at) a lower temperature **(1)**<br>• less energy required (for the reaction to proceed at an acceptable rate) or less burning of fossil fuels / less greenhouse gas evolved / less $CO_2$ evolved **(1)** | Allow lower temperature<br>Allow less energy costs<br>Ignore just cheaper<br>Ignore less time/faster rate<br>Allow less pollution | **2** |

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*21(b)</td>
<td>This question assesses the student’s ability to show a coherent and logically structured answer with linkages and fully sustained reasoning<br>Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.<br>The following table shows how the marks should be awarded for indicative content.<br>
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5-4</td><td>3</td></tr>
<tr><td>3-2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
The following table shows how the marks should be awarded for structure and lines of reasoning<br>
<table>
<tr><th></th><th>Number of marks awarded for structure of answer and sustained lines of reasoning</th></tr>
<tr><td>Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table>
</td>
<td>Guidance on how the mark scheme should be applied.<br>The mark for indicative content should be added to the mark for lines of reasoning. For example, a response with five indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).<br><br>If there were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).<br><br>In general it would be expected that 5 or 6 indicative points would get 2 reasoning marks, and 3 or 4 indicative points would get 1 mark for reasoning and 0, 1 or 2 indicative points would score zero marks for reasoning.<br>If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).<br>Comment: Look for the indicative marking points first, then consider the mark for the structure of the answer and sustained line of reasoning</td>
<td>6</td>
</tr>
</table>

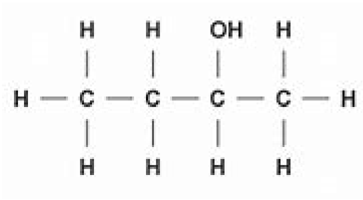
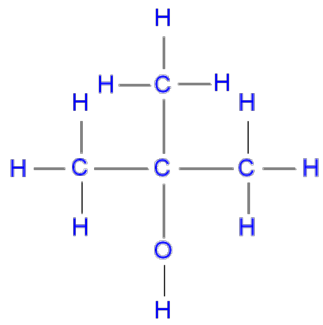
| | | | |
|---|---|---|---|
| | **Indicative content**<br><br><u>Potassium chloride</u><br><br>IP1 (misty/steamy fumes of) HCl/hydrogen chloride<br><br><u>Potassium iodide</u><br><br>IP2 purple vapour/black solid **and** $I_2$ /iodine<br><br>IP3 bad eggs **and** $H_2S$/ hydrogen sulfide<br>OR<br>yellow solid **and** S/ sulfur<br>OR<br>Choking gas **and** $SO_2$/sulfur dioxide<br><br>IP4 KCl is **not** a redox reaction and KI is a redox reaction /<br>KCl cannot reduce sulfuric acid but KI can<br><br>IP5 iodide stronger reducing agent than chloride | Note observation is not required for IP<br>This can be seen in an equation<br><br>Ignore any reference to hydrogen iodide/HI/misty fumes<br><br>The two parts of this answer may often be seen in different places.<br><br>Allow hydrogen iodide or potassium iodide is a stronger reducing agent than hydrogen chloride or potassium chloride.<br>Allow reducing ability (of the halides) increases down the group<br>Or reverse argument<br><br>Do not award iodine/I is a stronger reducing agent than chlorine/Cl | |

| | | | |
|---|---|---|---|
| | IP6 (because) S is reduced from +6 to – 2 in $H_2S$<br>OR<br>S is reduced from +6 to 0 in S<br>OR<br>S is reduced from +6 to + 4 in $SO_2$<br>OR<br>Any balanced equation making $H_2S$, $SO_2$, or S showing electrons<br>eg<br>$8H^+ + H_2SO_4 + 8e^- \longrightarrow H_2S + 4H_2O$<br>$2H^+ + H_2SO_4 + 2e^- \longrightarrow SO_2 + 2H_2O$<br>$6H^+ + H_2SO_4 + 6e^- \longrightarrow S + 4H_2O$ | Allow just correct stated product and oxidation number eg – 2 in $H_2S$ or 0 in S or + 4 in $SO_2$<br><br>Ignore $I_2$ oxidation number = 0 | |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **21(c)** | • number of moles of sulfuric acid in 40.5 $cm^3$ **(1)**<br><br>• concentration of the concentrated sulfuric acid **(1)** | <u>Example of calculation</u><br><br>1.5 × 500 ÷ 1000 = 0.75 (mol)<br><br>0.75 × 1000 ÷ 40.5 = 18.519 (mol $dm^{-3}$)<br><br>Allow TE on incorrect moles<br><br>Units not required but if given they must be correct<br><br>Correct answer with or without working scores **(2)**<br><br>Ignore SF except 1 SF | **2** |

**Total for Question 21 = 20 marks**

| Question Number | Answer | Additional Guidance | Mark |
| --- | --- | --- | --- |
| **22(a)** | An explanation that makes reference to the following points:<br><br>• contains the OH group/OH is the alcohol group **(1)**<br><br>• primary means the C bonded to the OH (group) is attached to 1 (or 0) alkyl group / carbon atom/ R group **(1)** | Accept a hydrocarbon in which one H atom has been replaced by an OH group<br>Allow contains O-H bond<br>Allow contains a C-OH bond<br>Ignore hydroxyl<br>Do not award hydroxide/ $OH^-$<br><br>Allow the OH group is attached to a carbon atom bonded to 2 (or 3) H atoms<br>Do not award the OH is attached to a single R/alkyl/carbon group | **2** |

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>22(b)</td><td>
<table>
<tr><td>Name</td><td>butan-1-ol</td><td></td><td>(2-)methylpropan-2-ol</td><td>(2)</td></tr>
<tr><td>Displayed formula</td><td></td><td></td><td></td><td>(2)</td></tr>
<tr><td>Nature of alcohol</td><td>primary</td><td>secondary</td><td></td><td>(1)</td></tr>
</table>
</td><td>One mark for each name<br><br>One mark for each correct displayed formula<br><br>One mark for both alcohol types<br><br>Allow $CH_3$ and OH undisplayed<br>Penalise missing Hs only once.</td><td>5</td></tr>
</table>

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **22(c)(i)** | An answer that makes reference to the following points:<br><br>• potassium dichromate((VI)) / $K_2Cr_2O_7$ **(1)**<br><br>• sulfuric acid / $H_2SO_4$ **(1)**<br><br>Note<br>M2 depends on M1 or a near miss such as potassium permanganate or potassium dichromate with the wrong oxidation number | Allow sodium dichromate((VI)) / $Na_2Cr_2O_7$<br>If oxidation state is given it must be correct<br>Do not award potassium manganate(VII) / potassium permanganate<br><br>Do not award hydrochloric acid<br>Ignore just 'acidified'<br>Ignore concentration of sulfuric acid<br>Ignore heat<br><br>If no other mark is scored acidified dichromate / $H^+$ and $Cr_2O_7^{2-}$ score (1) | **2** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **22(c)(ii)** | • $(CH_3)_2CHCH_2OH + [O] \rightarrow (CH_3)_2CHCHO + H_2O$ | Allow<br>$C_4H_{10}O + [O] \rightarrow C_4H_8O + H_2O$<br><br>The [O] may be above the arrow<br><br>Allow displayed/molecular/skeletal | **1** |

| Question Number | Answer | | Additional Guidance | Mark |
|---|---|---|---|---|
| **22(c)(iii)** | An answer that makes reference to two of the following points:<br><br>• (resulting mixture) would give a peak due to O−H bond in alcohols at 3750-3200 ($cm^{-1}$)<br><br>• would give a peak due to C=O bond in aldehydes at 1740-1720 ($cm^{-1}$)<br>or<br>would give a peak due to C−H bond in CHO at 2900-2820 and/ or 2775-2700 ($cm^{-1}$) | <br><br>**(1)**<br><br><br>**(1)** | Ignore any reference to the size/width of the peaks due to stretching etc<br><br>Allow (resulting mixture) would give a peak due to OH (in alcohols) at 3750-3200 ($cm^{-1}$)<br>Do not award -OH<br><br>Do not award 1720-1700 ($cm^{-1}$) for C=O in ketones<br><br>Allow any range within the range.<br>Do not award single numbers but penalise once only<br><br>If no other marks have been scored a correct wave number range for both the O-H and C=O score (1)<br>3750-3200 ($cm^{-1}$)<br>1740-1720 ($cm^{-1}$) | |

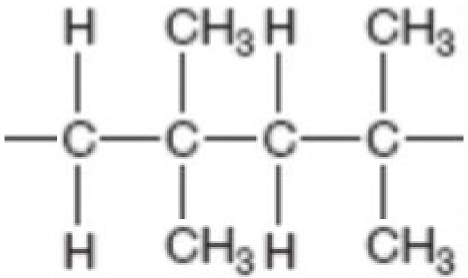
**(Total for Question 22 = 12 Marks)**

**Section C**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **23(a)(i)** | $TiO_2 + 2Cl_2 + 2C \rightarrow TiCl_4 + 2CO$ | Ignore state symbols even if incorrect<br>Allow multiples | **1** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **23(a)(ii)** | • Ti is reduced **and** from +4 to 0 **(1)**<br><br>• Mg is oxidised **and** from 0 to +2 **(1)** | Four correct oxidation numbers with no or incorrect mention of reduced or oxidised scores (1)<br>Ti is reduced as it gains electrons and Mg is oxidised as it loses electrons with no or incorrect oxidation numbers scores (1) | **2** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **23(b)** | • hydrolysis **(1)**<br><br>• titanium((IV)) oxide/$TiO_2$ **(1)** | Do not award hydration<br><br>Ignore hydrogen chloride/HCl<br>Allow titanium((IV))hydroxide/$Ti(OH)_4$<br><br>If both name and formula/oxidation number are given they must all be correct | **2** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| 23(c) | <br>• correct repeating unit **(1)**<br>• two repeating units and extension **(1)**<br><br>Note M2 depends on M1 or near miss eg missing a H | Allow adjacent pairs of methyl groups<br>Ignore square brackets and subscript n/2<br>Ignore connectivity of $CH_3$ | 2 |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **23(d)(i)** | An answer that makes reference to the following points:<br>• reagent: potassium hydroxide / KOH **(1)**<br>• conditions: aqueous/water **(1)**<br><br>M2 dependent on M1or near miss e.g. $OH^-$ will not score M1 but will allow access to M2. | Allow sodium hydroxide / NaOH<br><br>Ignore any reference to concentration or heat<br>Allow dilute | **2** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **23(d)(ii)** | An answer that makes reference to the following points:<br>• reagent: (concentrated) phosphoric((V)) acid / $H_3PO_4$ **(1)**<br>• reaction type: elimination/dehydration **(1)**<br><br>Independent marks | Allow (concentrated) sulfuric acid<br>Ignore heat<br>Do not award $H_3PO_3$<br>Allow passing vapour over porous pot / alumina or any surface catalyst **and** heat | **2** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **23(d)(iii)** | An answer that makes reference to the following points:<br><br>• reagent: phosphorus(V) chloride/ phosphorus pentachloride/$PCl_5$ **(1)**<br><br>• equation: $C_4H_9OH + PCl_5 \rightarrow C_4H_9Cl + HCl + POCl_3$ **(1)** | Allow thionyl chloride / $SOCl_2$<br>Allow phosphorus (III) chloride / phosphorus trichloride / $PCl_3$<br><br>Allow<br>$C_4H_9OH + SOCl_2 \rightarrow C_4H_9Cl + HCl + SO_2$<br>$3C_4H_9OH + PCl_3 \rightarrow 3C_4H_9Cl + H_3PO_3$<br><br>Allow skeletal, structural, displayed or molecular formulae | **2** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **23(d)(iv)** | An answer that makes reference to the following points:<br><br>• conditions: alcoholic **(1)**<br><br>• role of the hydroxide ions: base **(1)**<br><br>Note answers may be given on either line | Allow ethanol/ethanolic<br>Ignore heat and concentration<br><br>Allow proton acceptor/reacts with $H^+$ | **2** |

| Question Number | Answer | | Additional Guidance | Mark |
|---|---|---|---|---|
| 23(e) | An answer that makes reference to the following points: | | Examples of calculation | 5 |
| | • moles of carbon dioxide | **(1)** | $16 \div 44 = 0.36364$ (mol)/ $4 \div 11$(mol) | |
| | • conversion of $cm^3$ to $m^3$ | **(1)** | $20 \div 1000000 = 2 \times 10^{-5}$ / 0.00002 ($m^3$) | |
| | • conversion of $^oC$ to K | **(1)** | $273 + 25 = 298$ (K) | |
| | • rearrangement of the ideal gas equation | **(1)** | $p = \frac{nRT}{V}$ | |
| | • calculation of pressure and correct units given | **(1)** | $\frac{0.3636 \times 8.31 \times 298}{2 \times 10^{-5}}$ = 45025000 Pa / 45025 kPa<br>$4.5 \times 10^7$ Pa / 45MPa<br><br>Ignore SF except 1<br><br>Allow TE for answers to M1, M2 and M3<br>But no TE on wrong rearrangement of gas equation<br><br>Correct answer, including units with or without working scores **(5)** | |

**Total for Question 23 = 20 Marks**
**Total for Section C = 20 Marks**
**TOTAL FOR PAPER = 80 MARKS**

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