CAMBRIDGE
International Education

Cambridge International AS & A Level

CHEMISTRY **9701/41**

Paper 4 A Level Structured Questions **May/June 2024**

MARK SCHEME

Maximum Mark: 100

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the May/June 2024 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

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PUBLISHED

Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptions for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

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GENERIC MARKING PRINCIPLE 5: Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).
GENERIC MARKING PRINCIPLE 6: Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Science-Specific Marking Principles

1	Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
2	The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.
3	Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
4	The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
5	‘List rule’ guidance For questions that require ***n*** responses (e.g. State **two** reasons …): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked *ignore* in the mark scheme should not count towards ***n***. • Incorrect responses should not be awarded credit but will still count towards ***n***. • Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should **not** be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response. • Non-contradictory responses after the first ***n*** responses may be ignored even if they include incorrect science.

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6 Calculation specific guidance

Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'.

For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values.

For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme.

Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 Guidance for chemical equations

Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

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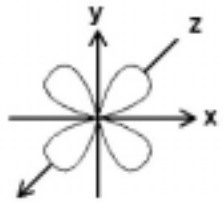
Question	Answer	Marks
1(a)(i)	**M1** strontium > calcium > magnesium **M2** ΔH_{latt} and ΔH_{hyd} both become less exothermic / less negative **M3** ΔH_{latt} changes more **M4** ΔH_{sol} becomes more exothermic / more negative	**4**
1(a)(ii)	pH increases as the concentration of $[OH^-]$ ions increases	**1**
1(b)	**M1** $[H^+] = 10^{-12.2}$ **OR** 6.31×10^{-13} **M2** $[OH^-] = 0.0158\ mol\ dm^{-3}$ ecf **M3** $[Ba(OH)_2] = 0.01585 \div 2 = 7.92$ ecf **M4** mol of $Ba(OH)_2 = 0.00792 \div 4 = 1.98 \times 10^{-3}$ mass $Ba(OH)_2 = 0.339\ g$ ecf	**4**
1(c)(i)	$K_{sp} = [Fe^{2+}][OH^-]^2$	**1**
1(c)(ii)	**M1** $K_{sp} = 4 \times (5.85 \times 10^{-6})^3 = 8.01 \times 10^{-16}$ **M2** $mol^3\ dm^{-9}$	**2**

Question	Answer	Marks
2(a)(i)	element which forms one or more stable ion with incomplete d orbitals	**1**
2(a)(ii)	they have vacant d orbitals that are energetically accessible	**1**
2(b)(i)	orbitals of the same energy	**1**
2(b)(ii)		**1**

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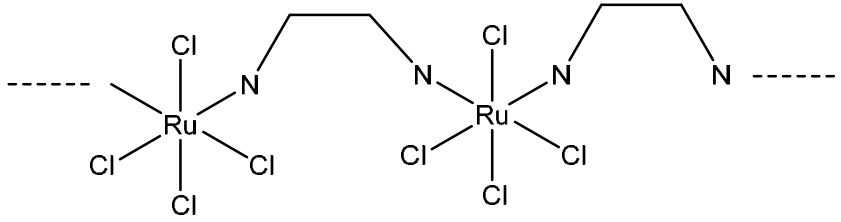
Question	Answer	Marks
2(c)	**M1** $2AgNO_3 + 2NaOH \rightarrow Ag_2O + 2NaNO_3 + H_2O$ **OR** $2Ag^+ + 2OH^- \rightarrow Ag_2O + H_2O$ **M2** $Ag_2O + 4NH_3 + H_2O \rightarrow 2[Ag(NH_3)_2]OH$ **OR** $Ag^+ + 2NH_3 + OH^- \rightarrow [Ag(NH_3)_2]OH$	**2**
2(d)	**M1** bond angle H–N–Ag is 109.5° **M2** shape is linear **AND** bond angle for N–Ag–N is 180°	**2**
2(e)	**M1** $Ag_2O + H_2O + 2e^- \rightarrow 2Ag + 2OH^-$ **M2** $Zn + 2OH^- \rightarrow Zn(OH)_2 + 2e^-$	**2**
2(f)	For example:  **M1** presence of *dps* ligand bonded to two Ru **M2** the rest of the structure correct	**2**

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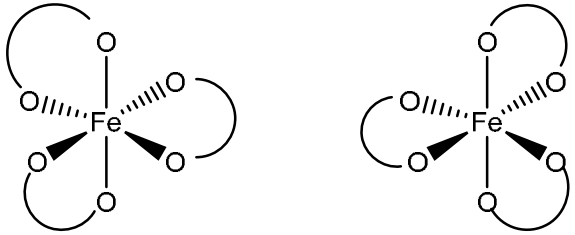
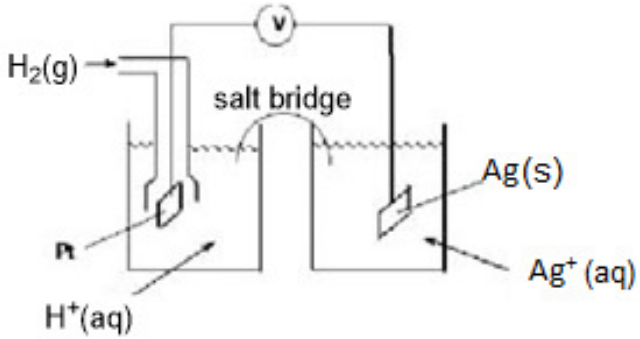
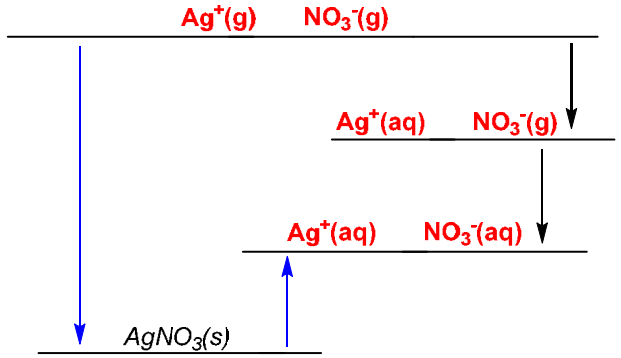
Question	Answer	Marks
3(a)	$Li_2C_2O_4•H_2O \rightarrow Li_2CO_3 + H_2O + CO$	**1**
3(b)	**M1** CaC_2O_4 **AND** Ca^{2+} has a smaller ionic radius / Ca^{2+} has a higher charge density **M2** anion / $C_2O_4^{2-}$ becomes more polarised / distorted	**2**
3(c)	**M1** d orbital(s) of different energy / d-d splitting occurs **M2** electron(s) promoted / excited **M3** light is absorbed **AND** colour seen is complementary	**3**
3(d)	$2K_3Fe(C_2O_4)_3 \rightarrow 2K_2Fe(C_2O_4)_2 + K_2C_2O_4 + 2CO_2$	**1**
3(e)		**2**
3(f)	**M1** $HC_2O_4^- + H^+ \rightarrow H_2C_2O_4$ **M2** $HC_2O_4^- + OH^- \rightarrow C_2O_4^{2-} + H_2O$	**2**
3(g)	**M1** $2C_2O_4^{2-} + O_2(g) + 2H_2O(l) \rightarrow 4CO_2(g) + 4OH^-(aq)$ **M2** $E_{cell} = 0.40 - (-0.59) = 0.99\,V$	**2**

Question	Answer	Marks
4(a)	**M1** voltage of a half-cell compared to SHE **M2** 1 mol dm^{-3} **AND** 101 kPa **AND** 298 K	**2**
4(b)(i)	 **M1** Pt Ag Ag^+ **M2** gas delivery system H_2 H^+ **M3** voltmeter salt bridge wiring Pt to V to Ag	**3**
4b(ii)	*E* value would be more negative **AND** shifts $Ag^+ (+ e^-) \leftrightharpoons Ag$ to the left	**1**
4(c)	enthalpy change when one mole of a solute dissolves in water	**1**
4(d)(i)	 **M1** two arrows in blue **M2** correct species in red with all state symbols	**2**

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Question	Answer	Marks
4(d)(ii)	ΔH_{latt} = –811.6 (kJ mol^{-1})	**1**
4(e)	**M1** $Mg(NO_3)_2$(s), $NaNO_3$(s), $RbNO_3$(s) **M2** Mg^{2+} has a higher charge than Na^+ **OR** Rb^+ **AND** Na^+ has a smaller radius than Rb^+ **M3** correct statement relating magnitude of LE to attraction between ions **OR** strength of ionic bonds	**3**

Question	Answer	Marks
5(a)(i)	tangent drawn at t = 0 **AND** gradient of tangent calculated at t = 0 answer between 0.016 to 0.040	**1**
5(a)(ii)	$[I^-]$ stays constant / $[I^-]$ does not change **OR** the overall order is one under these conditions	**1**
5(b)	**M1** equation 1: $2Fe^{2+} + S_2O_8^{2-} \rightarrow 2Fe^{3+} + 2SO_4^{2-}$ **M2** equation 2: $2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$	**2**
5(c)	the rate constant and rate of reaction 1 will both increase	**1**
5(d)	$k = 0.693 \div t_{½}$ $t_{½}$ = 0.693 ÷ 0.0158 = 43.9 s	**1**
5(e)	$NO + Br_2 \rightarrow NOBr_2$ **OR** $NO + Br_2 \rightarrow NOBr + Br$ $NOBr_2 + NO \rightarrow 2NOBr$ **OR** $Br + NO \rightarrow NOBr$ **M1** two equations adding up to the overall equation **M2** step 1 has one NO and one Br_2 only and is identified as slow step	**2**

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>6(a)(i)</td><td>ratio of the concentrations of solute in two solvents</td><td>1</td></tr>
<tr><td>6(a)(ii)</td><td>M1 10.5 = (y ÷ 25) ÷ ((0.74–y) ÷ 40)
M2 y = 0.642 g</td><td>2</td></tr>
<tr><td>6(b)</td><td><table><tr><th></th><th>sp</th><th>sp^2</th><th>sp^3</th></tr><tr><td>Kekulé benzene</td><td>0</td><td>6</td><td>0</td></tr><tr><td>Dewar benzene</td><td>0</td><td>4</td><td>2</td></tr><tr><td>Ladenburg benzene</td><td>0</td><td>0</td><td>6</td></tr></table>M1 row 1 and 2 correct
M2 row 3 correct</td><td>2</td></tr>
<tr><td>6(c)</td><td>M1 120° AND hexagonal/trigonal planar

M2 C-C has π-bonds and σ-bonds AND C-H have σ-bonds only</td><td>2</td></tr>
<tr><td>6(d)</td><td>bond strain OR ring strain</td><td>1</td></tr>
<tr><td>6(e)</td><td><table><tr><th></th><th>peaks</th></tr><tr><td>Dewar benzene</td><td>2</td></tr><tr><td>Ladenburg benzene</td><td>1</td></tr><tr><td>delocalised benzene</td><td>1</td></tr></table></td><td>1</td></tr>
<tr><td>6(f)(i)</td><td>$BrCH_2CH_2CH_2CH_2Br + FeBr_3 \rightarrow BrCH_2CH_2CH_2CH_2^+ + FeBr_4^-$</td><td>1</td></tr>
</table>

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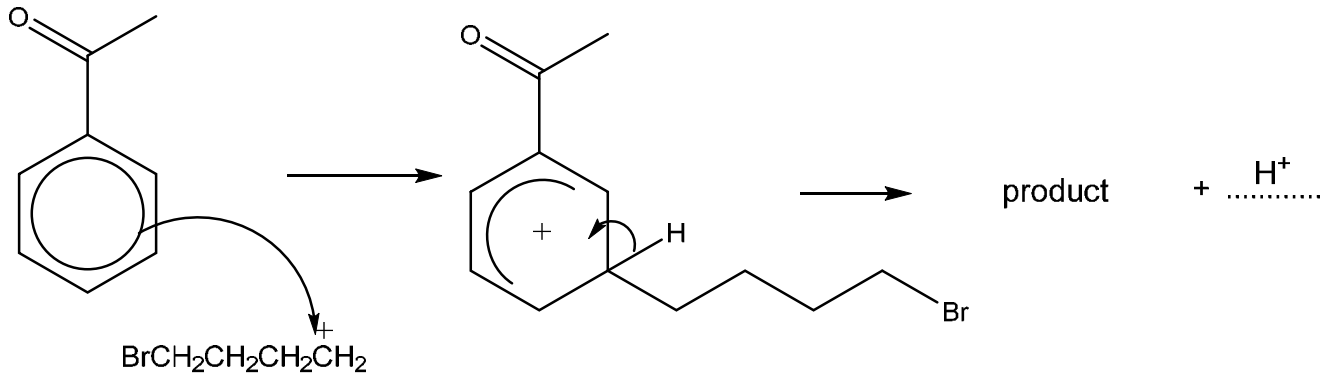
Question	Answer	Marks
6(f)(ii)	 **M1** curly arrow from inside the hexagon towards C^+ **M2** structure of the intermediate **M3** curly arrow from C–H bond into the ring **AND** H^+	**3**

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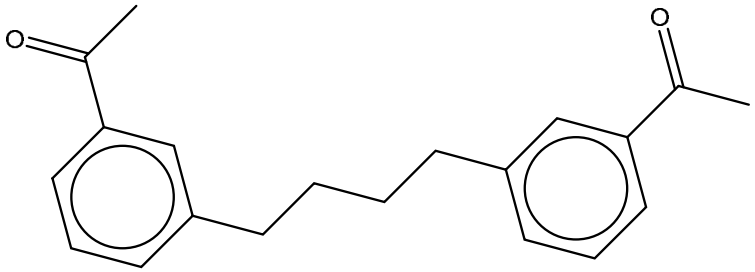
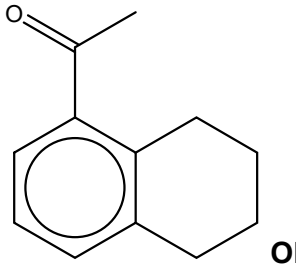
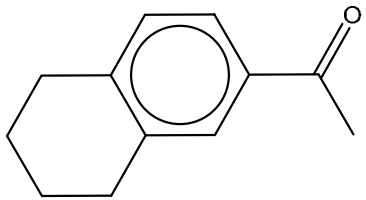
Question	Answer	Marks
6(f)(iii)	**M1** **Y**  **M2** **Z**  **OR** 	**2**

Question	Answer	Marks
7(a)	methyl pentanoate	**1**
7(b)(i)	time between injection and detection	**1**
7(b)(ii)	29.5%	**1**

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>7(c)(i)</td><td>
<table>
<tr><th>ester</th><th>number of peaks seen in proton (^{1}H) NMR</th><th>number of peaks seen in carbon-13 NMR</th></tr>
<tr><td>B</td><td>5</td><td>6</td></tr>
<tr><td>C</td><td>4</td><td>5</td></tr>
</table>
M1 row 1 correct
M2 row 2 correct
</td><td>2</td></tr>
<tr><td>7(c)(ii)</td><td>A and B</td><td>1</td></tr>
</table>

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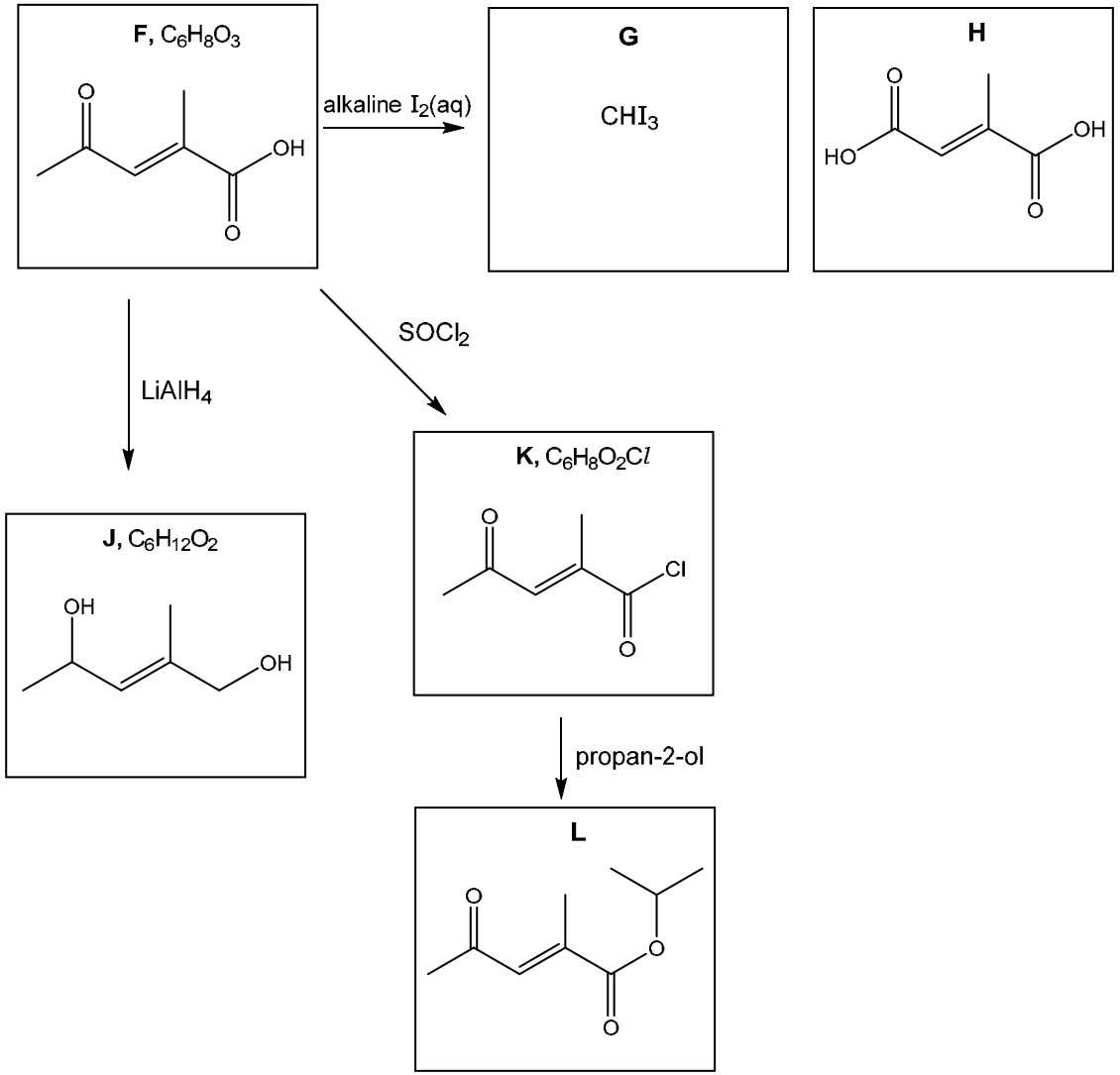
Question	Answer	Marks
7(d)	 one mark for each structure: **F**, **G**, **H**, **J**, **K** and **L**	**6**

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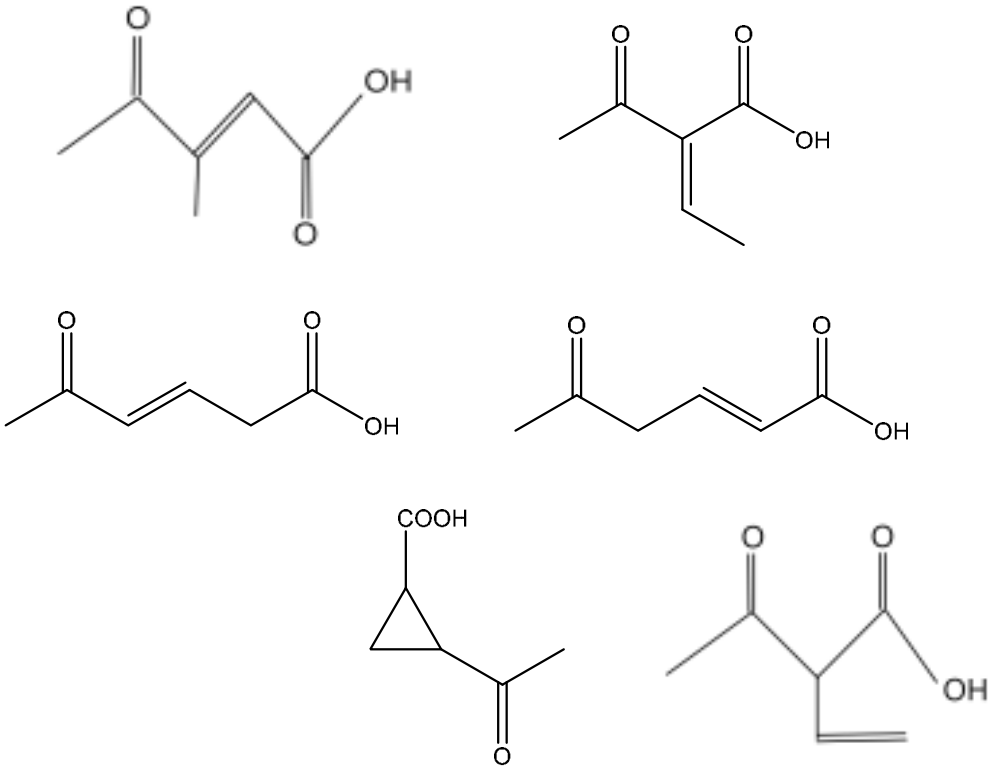
Question	Answer	Marks
7(d)	six alternatives for **F** 	

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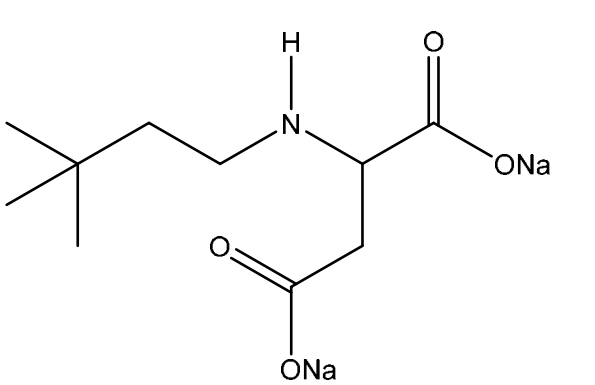
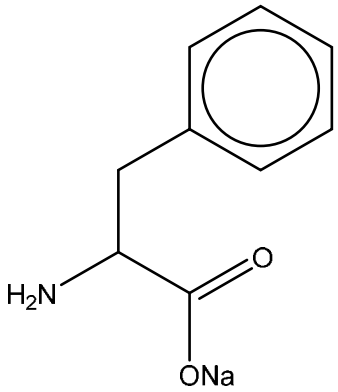
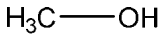
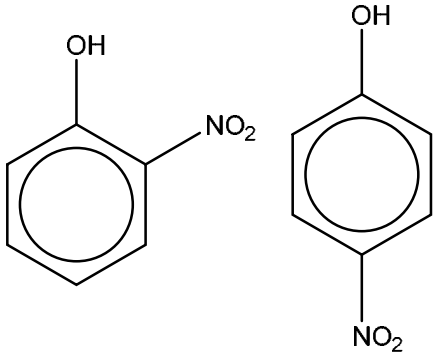
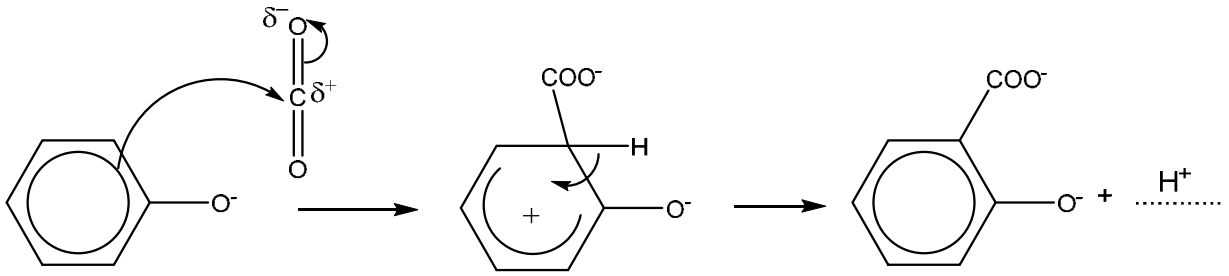
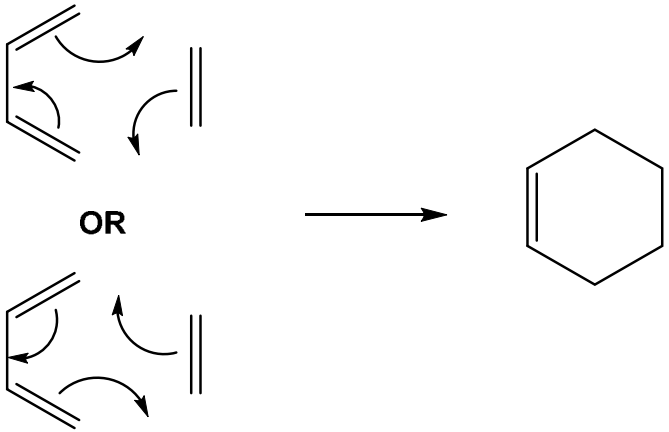
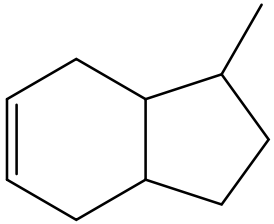
Question	Answer	Marks
8(a)(i)	two	**1**
8(a)(ii)	amide amine ester carboxylic acid / carboxyl any two [1] all four [2]	**2**
8(b)(i)	**M1** hydrolysis **M2** acid–base	**2**
8(b)(ii)	   one mark for each structure	**3**

Question	Answer	Marks
9(a)(i)	$C_6H_5OH + Na \rightarrow C_6H_5ONa + ½H_2$	**1**
9(a)(ii)	 both structures for one mark	**1**
9(b)	 **M1** correct dipole **AND** curly arrow from inside the hexagon to the carbon atom **M2** structure of the intermediate **M3** curly arrow from C-H bond into the ring **AND** H^+	**3**

Question	Answer	Marks
9(c)(i)	 All three curly arrows for one mark	**1**
9(c)(ii)		**1**