SPECIMEN MATERIAL v1.0

A-LEVEL
Chemistry

Paper 2: Organic and Physical Chemistry
Mark scheme

7405/2
Specimen Paper (set 2)

Version 1.0

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this Mark Scheme are available from aqa.org.uk

Important - please note

This mark scheme has not been through the full standardisation process. As such, many of the phases described above have not been completed. The Instructions for examiners are also included as a guide to how the mark scheme will function as an operational document. The layout has been kept consistent so that future operational mark schemes do not appear different to the specimen materials.

AS and A-level Chemistry

Mark scheme instructions for examiners

Introduction to marking

Before beginning the standardisation process, you must:

- access the online tutorial
- access all relevant documents on your Examiner Extranet page
- mark a minimum of 10 training clips of each item.

When standardising online, you must review the marking of the standardisation clips and all comments and annotations made by the Lead Examiner, which exemplify the marking standard. You must discuss the results of your marking of the standardisation clips with your Team Leader before you will be cleared to mark live clips.

1. General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- the typical answer or answers which are expected
- extra information to help the examiner make his or her judgement and help to delineate what is acceptable or not worthy of credit or, in discursive answers, to give an overview of the area in which a mark or marks may be awarded.

The extra information in the 'Comments' column is aligned to the appropriate answer in the left-hand part of the mark scheme and should only be applied to that item in the mark scheme.

You should mark according to the contents of the mark scheme. If you are in any doubt about applying the mark scheme to a particular response, consult your Team Leader.

At the beginning of a part of a question a reminder may be given, for example: where consequential marking needs to be considered in a calculation; or the answer may be on the diagram or at a different place on the script.

In general the right-hand side of the mark scheme is there to provide those extra details which confuse the main part of the mark scheme yet may be helpful in ensuring that marking is straightforward and consistent.

The use of M1, M2, M3 etc refers to the marking points in the order in which they appear in the mark scheme. So, M1 refers to the first marking point, M2 the second marking point etc.

2. Emboldening

2.1 In a list of acceptable answers where more than one mark is available 'any **two** from' is used, with the number of marks emboldened. Each of the following bullet points is a potential mark.

2.2 A bold **and** is used to indicate that both parts of the answer are required to award the mark.

2.3 Alternative answers acceptable for a mark are indicated by the use of **OR**. Different terms in the mark scheme are shown by a / ; eg allow smooth / free movement.

3. Marking points

3.1 Marking of lists

This applies to questions requiring a set number of responses, but for which students have provided extra responses. The general principle to be followed in such a situation is that 'right + wrong = wrong'.

Each error / contradiction negates each correct response. So, if the number of error / contradictions equals or exceeds the number of marks available for the question, no marks can be awarded.

However, responses considered to be neutral (often prefaced by 'Ignore' in the mark scheme) are not penalised.

3.2 Marking procedure for calculations

Full marks should be awarded for a correct numerical answer, without any working shown, unless the question states 'Show your working' or 'justify your answer'.

If an answer to a calculation is incorrect and working is shown, process mark(s) can usually be gained by correct substitution / working. This is usually shown in the 'Comments' column or by each stage of a longer calculation.

3.3 Equations

In questions requiring students to write equations, state symbols are generally ignored unless otherwise stated in the 'Comments' column.

Examiners should also credit correct equations using multiples and fractions unless otherwise stated in the 'Comments' column.

Equations are not correct unless they are balanced.

3.4 Organic structures

Where students are asked to draw organic structures, these may be given as displayed, structural or skeletal formulas unless a specific type of structure is required in the question and stated in the mark scheme.

3.5 Interpretation of 'it'

Answers using the word 'it' should be given credit only if it is clear that the 'it' refers to the correct subject.

3.6 Errors carried forward, consequential marking and arithmetic errors

Allowances for errors carried forward are most likely to be restricted to calculation questions and should be shown by the abbreviation ECF or consequential in the marking scheme.

An arithmetic error should be penalised for one mark only unless otherwise amplified in the marking scheme. Arithmetic errors may arise from a slip in a calculation or from an incorrect transfer of a numerical value from data given in a question.

3.7 Phonetic spelling

The phonetic spelling of correct scientific terminology should be credited **unless** there is a possible confusion with another technical term or if the question requires correct IUPAC nomenclature.

3.8 Brackets

(…..) are used to indicate information which is not essential for the mark to be awarded but is included to help the examiner identify the sense of the answer required.

3.9 Ignore / Insufficient / Do not allow

Ignore or insufficient is used when the information given is irrelevant to the question or not enough to gain the marking point. Any further correct amplification could gain the marking point.

Do **not** allow means that this is a wrong answer which, even if the correct answer is given, will still mean that the mark is not awarded.

3.10 Marking crossed out work

Crossed out work that **has not been** replaced should be marked as if it were not crossed out, if possible. Where crossed out work **has been** replaced, mark the replacement work and not the crossed out work.

3.11 Extended responses

For questions marked using a 'Levels of Response' mark scheme:

Level of response mark schemes are broken down into three levels, each of which has a descriptor. Each descriptor contains two statements. The first statement is the Chemistry content statement and the second statement is the communication statement.

Determining a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the Chemistry content descriptor for that level. The descriptor for the level indicates the qualities that might be seen in the student's answer for that level. If it meets the lowest level, then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level.

Once the level has been decided, the mark within the level is determined by the communication statement:

- If the answer completely matches the communication descriptor, award the higher mark within the level.
- If the answer does not completely match the communication descriptor, award the lower mark within the level.

The exemplar materials used during standardisation will help you to determine the appropriate level. There will be an exemplar in the standardising materials which will correspond with each level of the mark scheme and for each mark within each level. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the exemplar to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the exemplar.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other chemically valid points. Students may not have to cover all of the points mentioned in the indicative content to reach the highest level of the mark scheme. The mark scheme will state how much chemical content is required for the highest level.

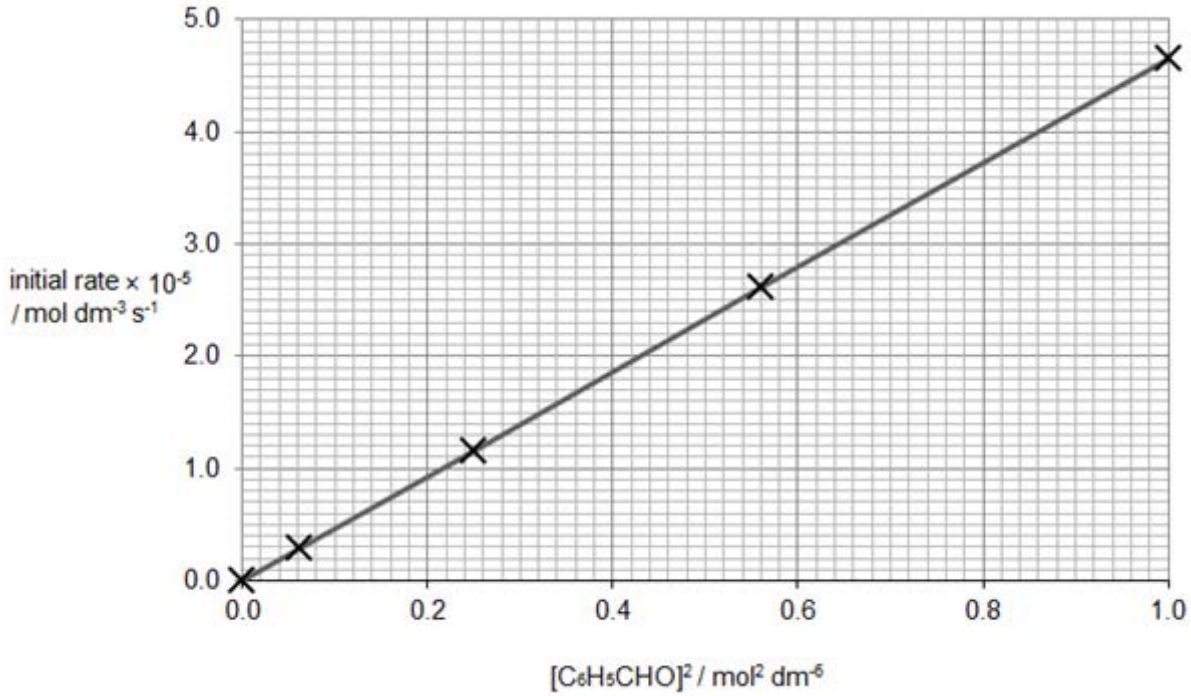
An answer which contains nothing of relevance to the question must be awarded no marks.

For other extended response answers:

Where a mark scheme includes linkage words (such as 'therefore', 'so', 'because' etc), these are optional. However, a student's marks for the question may be limited if they do not demonstrate the ability to construct and develop a sustained line of reasoning which is coherent, relevant, substantiated and logically structured. In particular answers in the form of bullet pointed lists may not be awarded full marks if there is no indication of logical flow between each point or if points are in an illogical order.

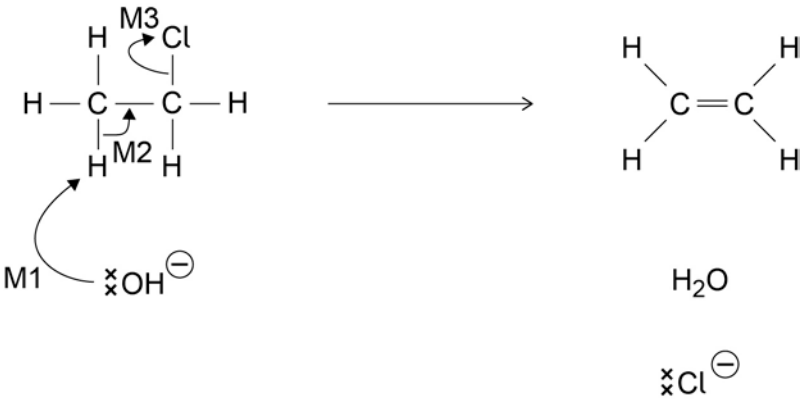
The mark schemes for some questions state that the maximum mark available for an extended response answer is limited if the answer is not coherent, relevant, substantiated and logically structured. During the standardisation process, the Lead Examiner will provide marked exemplar material to demonstrate answers which have not met these criteria. You should use these exemplars as a comparison when marking student answers.

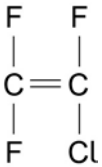
Question	Marking Guidance	Mark	Comments
01.1	**Stage 1: Calculates value of $[C_6H_5CHO]^2$:** M1 for the values (0, 0.0625; 0.25; 0.56 and 1) in the table **Stage 2: Plots graph:** M2 for the graph labels with units and appropriate scales and using sensible proportion of graph (plotted points must cover at least half the printed grid) M3 for the plotting of 5 points **Stage 3: Line of best fit:** M4 for the line of best fit	 1 1 1 1	Ignore precision $[C_6H_5CHO]^2$ on *x*-axis (with units) $mol^2\ dm^{-6}$ Initial rate on *y*-axis (with units) $mol\ dm^{-3}\ s^{-1}$

01.1 continued			

01.2	2nd order (since) $[C_6H_5CHO]^2$ plotted against rate is straight line / directly proportional	1 1	

01.3	(Role of CN^-) catalyst CN^- appears in the rate equation but is not in the reaction equation	1 1	Ignore nucleophile

Question	Marking Guidance	Mark	Comments
02.1	$Cl\bullet + O_3 \longrightarrow ClO\bullet + O_2$ $ClO\bullet + O_3 \longrightarrow 2O_2 + Cl\bullet$	1 1	Allow dot in free-radical on either O or Cl
02.2	(KOH acts as a) base (propan-1-ol acts as a) solvent	1 1	 Allow product of reaction between KOH and propan-1-ol / $CH_3CH_2CH_2O^-$ acts as base
02.3	(name of mechanism) Elimination mechanism: 3 arrows (1 mark each)  	1 3	

02.4		1	

<table>
<tr><th>Question</th><th colspan="2">Marking Guidance</th><th>Mark</th><th>Comments</th></tr>
<tr><td>02.5</td><td colspan="2">This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.</td><td>6</td><td rowspan="3">Indicative chemistry content

Stage 1 (determines empirical formula)
1a 16.3% carbon
1b Divide by A_r
1c Divide by smallest (0.904)
1d Convert ratio in simplest integer (x 2)

<table><tr><td>C</td><td>Cl</td><td>F</td></tr><tr><td>$\frac{16.3}{12.0}$ = 1.358</td><td>$\frac{32.1}{35.5}$ = 0.904</td><td>$\frac{51.6}{19.0}$ = 2.716</td></tr><tr><td>$\frac{1.358}{0.904}$</td><td>$\frac{0.904}{0.904}$</td><td>$\frac{2.716}{0.904}$</td></tr><tr><td>3</td><td>2</td><td>6</td></tr></table>
Stage 2 (determines formulae of three molecular ions)
2a For E.F. M_r (corresponds to the molecule) = 221
2b since M_r = 221 lies within molecular ion range 220–224
2c Thus empirical formula = molecular formula
2d Three correct formulae
2e Correct M_r for each of three molecules

<table><tr><td>$C_3{}^{35}Cl_2F_6{}^{+\cdot}$</td><td>$C_3{}^{35}Cl{}^{37}ClF_6{}^{+\cdot}$</td><td>$C_3{}^{37}Cl_2F_6{}^{+\cdot}$</td></tr><tr><td>220</td><td>222</td><td>224</td></tr></table></td></tr>
<tr><td></td><td>Level 3
5–6 marks</td><td>All stages are covered & the explanation of each stage is generally correct and virtually complete. Stages 1 and 2 are supported by correct data. Answer communicates the whole process coherently and shows a logical progression from stage 1 to stage 2 and then stage 3.

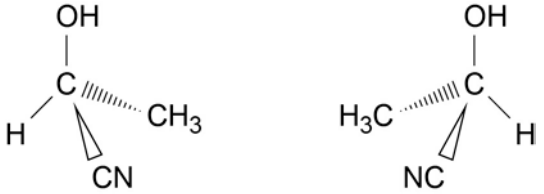
Steps in stage 3 are in logical order and working is shown. If there is no working for ratio or statement of ratio (then full marks cannot be awarded.

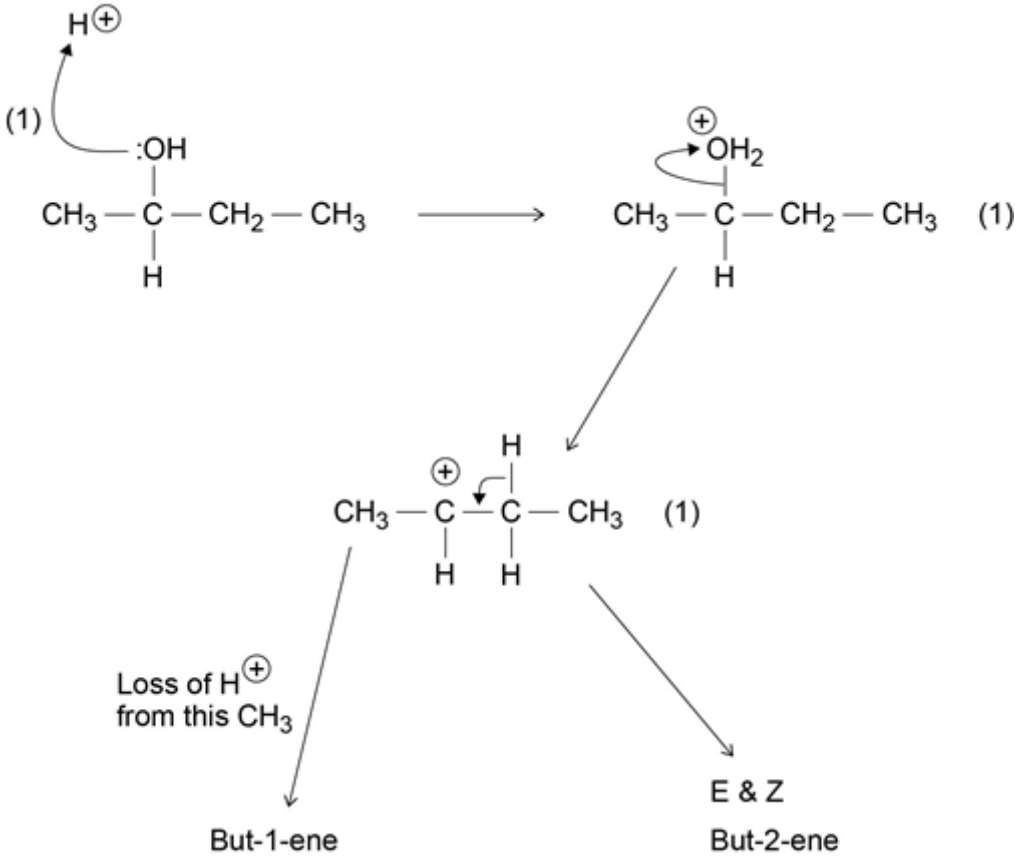
If the formulae of the three molecular ions are not correct (2d) then the student can’t access Level 3 (any incorrect chemistry drops the student to the bottom mark within the level they have achieved).</td><td></td></tr>
<tr><td></td><td>Level 2
3–4 marks</td><td>Stage 2 is attempted (2a-2c do not need to be explicitly stated) but the calculation may contain inaccuracies OR the explanation may be incomplete OR first two stages are covered and the explanations are generally correct and virtually complete. Answer is mainly coherent and shows a progression through the first two stages. Some steps in each stage may be incomplete.

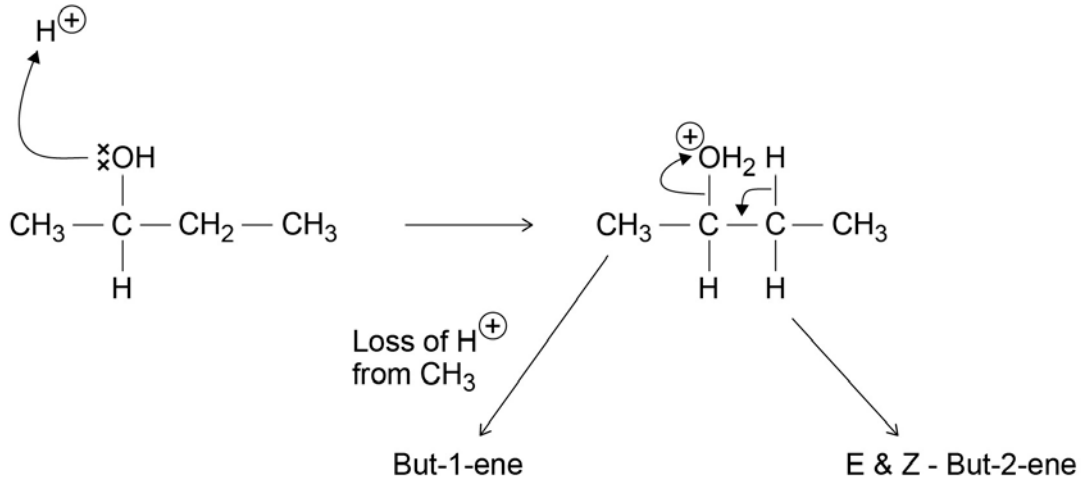
If percentage of carbon is missing or incorrect (1a) then student can’t access Level 2.</td><td></td></tr>
</table>

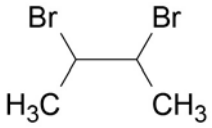
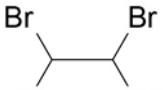
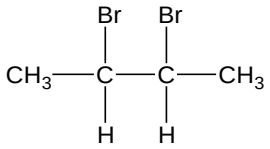
	Level 1 1–2 marks	Stage 1 needs to be attempted but may contain inaccuracies OR Stage 3 attempted but may contain inaccuracies / molecular formula not determined. Answer includes some isolated statements, but these are not presented in a logical order or show confused reasoning		**Stage 3 (explains the ratio of 3 molecular ion peaks)** **3a** Working **3b** Correct (simplified) ratio **9:6:1** Note: 9:3:1 will be a common incorrect answer (max 5) Working:
	Level 0 0 marks	Insufficient correct chemistry to warrant a mark.		

$C_3{}^{35}Cl_2F_6{}^{+\cdot}$	$C_3{}^{35}Cl^{37}ClF_6{}^{+\cdot}$	$C_3{}^{37}Cl_2F_6{}^{+\cdot}$
220	222	224
$^{35}Cl_2 = (\frac{3}{4})^2 = \frac{9}{16}$	$^{35}Cl^{37}Cl$ and $^{37}Cl^{35}Cl = 2 \times \frac{1}{4} \times \frac{3}{4} = \frac{6}{16}$	$^{37}Cl_2 = (\frac{1}{4})^2 = \frac{1}{16}$

Question	Marking Guidance	Mark	Comments
03.1	3	1	
03.2	Chain	1	
03.3		1 1	One 3D enantiomer Second enantiomer correctly drawn as 3D mirror image of first
03.4	Plane-polarised light Rotated in opposite directions	1 1	

03.5	Elimination  	8	Extended response question M1 **Mechanism** (3 marks) M2 arrow from lone pair on O to H^+ M3 1st intermediate **and** arrow from C—O^+H_2 bond to O (with loss of H_2O) M4 2nd intermediate (carbocation) **and** arrow from C—H bond to C—C (with loss of H^+) to form C=C M3 and M4 can be scored in one step (see alternative mechanism on next page) If carbocation incorrect then answer cannot score maximum marks

03.5 continued	**Explanation** of formation of 3 alkenes M5 loss of H^+ from C (in carbocation) adjacent to ^+C (to which –OH was attached) M6 From $^{1}\mathbf{C}$–$^{2}C^{+}$–^{3}C–^{4}C leads to but-1-ene M7 From ^{1}C–$^{2}C^{+}$–$^{3}\mathbf{C}$–^{4}C leads to but-2-ene M8 But-2-ene formed as mixture of *E-Z* isomers		
	Alternative mechanism  		

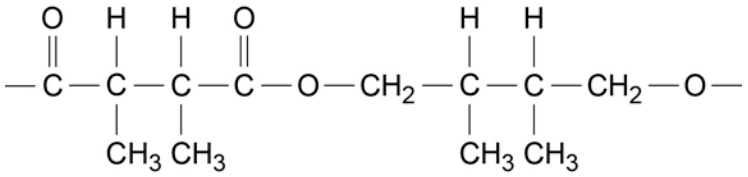
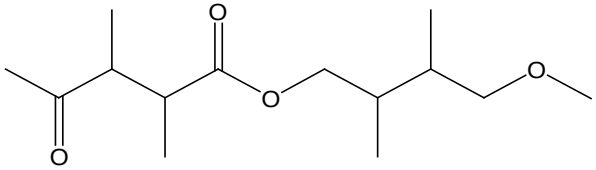
Question	Marking Guidance	Mark	Comments
04.1	2,3-dimethylbutane(-1,4-)dioic acid	1	penalise other numbers Ignore hyphens, commas, spaces
04.2	**D** =  OR  **Step 1:** HBr Electrophilic addition **Step 2:** KCN Nucleophilic substitution **Step 3:** Hydrolysis	1 1 1 1 1 1	Allow displayed formula  Not HCN, not KCN with acid

04.3

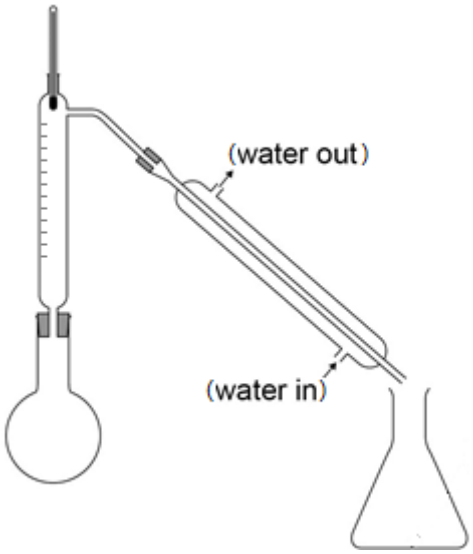
	Mark
Reagent	1
Observation with **F**	1
Observation with **G**	1

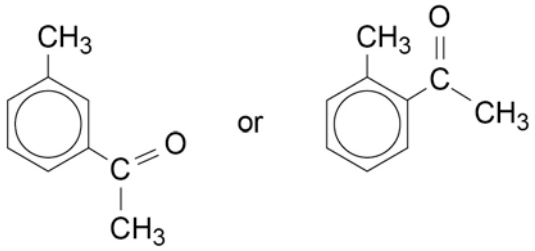
$K_2Cr_2O_7$ & H_2SO_4 (allow acidified)	**Mg**	**Na_2CO_3 or $NaHCO_3$**
F: no visible change	**F**: effervescence	**F**: effervescence
G: orange to green	**G**: no visible change	**G**: no visible change

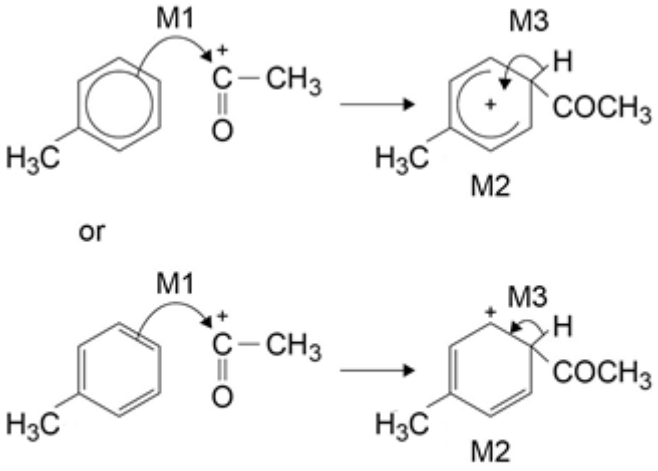
Named alcohol <u>and</u> conc. sulfuric acid	**Named carboxylic acid <u>and</u> conc. sulfuric acid**
F: pleasant smell	**F**: no visible change
G: no visible change	**G**: pleasant smell

04.4	 or 	1 1	Two ester groups One unit only must have trailing bonds ignore n and brackets

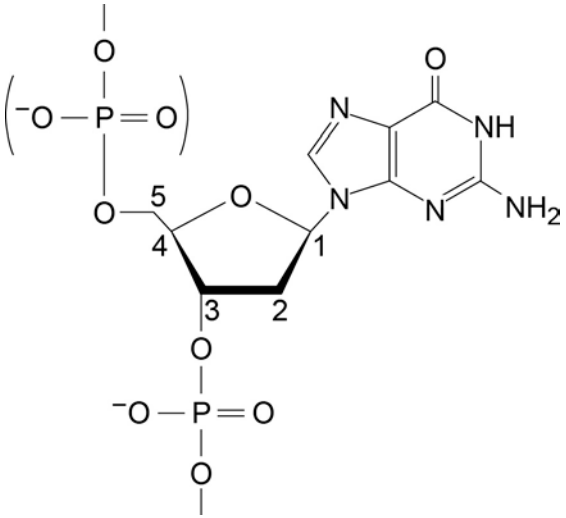
04.5	Mass of **G** = (1.11 × 10^3) cm^3 × 1.04 g cm^{-3} = 1154 g		1	65.1 scores 4 marks
	Amount of **G** $\frac{1154}{Mr = 118}$ = 9.78 mols		1	
	Amount of **F** (actual) = $\frac{930}{Mr = 146}$ = 6.37 mol	Expected mass of **F** = 9.78 × (M_r =) *146* = 1428 g	1	
	% yield = $\frac{6.37}{9.78}$ × 100 = 65.1(%)	% yield = $\frac{930}{1428}$ x 100 = 65.1 (%)	1	M4 answer must be to 3 significant figures

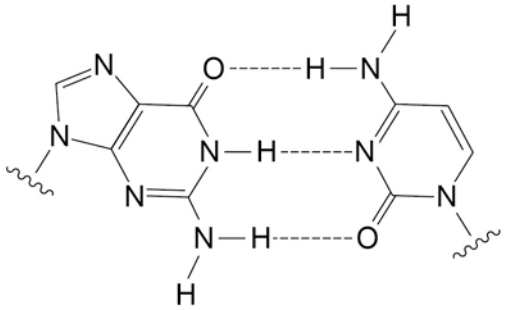
04.6	Fractional distillation  	1 1 1 1	A rough labelled sketch illustrating these points scores the marks Apparatus for fractional distillation must clearly work with fractionating column Fractionating column and thermometer Condenser / water jacket Ignore heat source

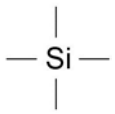
Question	Marking Guidance	Mark	Comments
05.1	$C_9H_{10}O$	1	
05.2	 or	1	
	Position (isomerism)	1	Do not allow Positional

05.3	Electrophilic substitution	1	
	$CH_3COCl + AlCl_3 \rightarrow CH_3CO^+ + AlCl_4^-$	1	
			Mechanism 3 marks: **M1** arrow from circle or within it to C of CH_3C^+O (+ must be on C of CH_3C^+O) **M2** for Intermediate (**must** be 4-isomer) CH_3CO must be correctly positioned and bonded to gain M2 horseshoe must not extend beyond C2 to C6 but can be smaller + not too close to C1 **M3** arrow into hexagon unless Kekule Loss of H^+ (allow from incorrect isomer) Allow M3 arrow independent of M2 structure Ignore base removing H in M3 Allow Kekule structures (which must be correct)

Question	Marking Guidance	Mark	Comments
06.1	**Gas chromatography explanation**		
	Different retention times/dipeptides appear at different times	1	
	Different balance between solubility in the moving phase/gas carrier **and** retention by the stationary phase/column OR different relative affinity for mobile and stationary phases.	1	
	Mass spectrometry explanation		
	Same *m/z* values	1	
	(Both) dipeptides/**J** and **K** have same molecular formula/M_r	1	
06.2	ser-ala	1	
	ala-lys	1	
	ser-ala-lys	1	This order only

Question	Marking Guidance	Mark	Comments
07.1			CE=0 if **nucleotide** does not contain one base, one sugar and one phosphate Max 2 for any slips in structures
	Correct phosphate-sugar link on C3	1	Allow phosphate attached to C5
	Correct sugar-guanine link on C1	1	
	Remainder of molecule correct	1	

07.2	 Correct diagram of cytosine (base pair with guanine) Three hydrogen bonds drawn	 1 1	 CE=0 if wrong base shown Allow M2 if slip in M1
07.3	There are only two H-bonds in the adenine-thymine base pair	1	Allow there is one fewer H-bond in the AT base pair
07.4	The amino/-NH_2 groups in urea are able to substitute for the H–bonds in the double helix	1 1	 Allow H bonds will form between the urea and the DNA strands

Question	Marking Guidance	Mark	Comments
08.1		1	*1xAO1*
08.2	**S** **R** **Q**	1 1 1	
08.3	(Isomer **T**) signals due to OH (alcohol) at 3230–3350 and C=O at 1680–1750 OH and C=O (functional groups) separated in molecule (Isomer **U**) (only) signal for OH (alcohol) at 3230–3350 2 × OH groups present / diol / OH & cyclo(ether) structure (Isomer **V**) signals due to OH (acid) at 2500–3000 (and C=O at 1680–1750) carboxylic acid group / –COOH present	 1 1 1 1 1 1	 Allow not a carboxylic acid Allow OH but not C=O
08.4	2:2:2:3:3	1	Any order

08.5	(The quartet at δ=3.5 is for a CH_2 group) next to $-O-CH_2$ OR shifted significantly downfield by electronegative O (is a quartet) because of an adjacent CH_3 group / couple with 3 adjacent protons (singlet at δ=2.2 is for a CH_3 group) attached to $-C(=O)-CH_3$ OR shifted downfield by electronegative C=O (is a singlet) because there are no adjacent protons / no coupling	1 1 1 1	
08.6	$CH_3-CH_2-O-CH_2-CH_2-C(=O)-CH_3$	2	Allow 1 mark for: $CH_3-O-CH_2-CH_2-C(=O)-CH_2-CH_3$

<table>
<tr><th>Question</th><th>Marking Guidance</th><th>Mark</th><th>Comments</th></tr>
<tr><td>9.1</td><td>
Stage 1: Complete table and draws graph:
<table>
<tr><th>Rate constant k / s^{-1}</th><th>ln k</th><th>Temperature / K</th><th>$\frac{1}{T}$</th></tr>
<tr><td>6.13×10^{-5}</td><td>–9.7(0)</td><td>700</td><td>1.43×10^{-3}</td></tr>
<tr><td>2.75×10^{-4}</td><td>–8.2(0)</td><td>727</td><td>1.38×10^{-3}</td></tr>
<tr><td>8.25×10^{-4}</td><td>–7.1(0)</td><td>746</td><td>1.34×10^{-3}</td></tr>
<tr><td>8.23×10^{-3}</td><td>–4.8(0)</td><td>793</td><td>1.26×10^{-3}</td></tr>
</table>
Stage 2: Calculates gradient:
M5 working = $\frac{\Delta y}{\Delta x}$ (such as $\frac{-6.9}{0.24 \div 1000}$ or $\frac{-5.5}{0.19 \div 1000}$)
M6 answer = -2.88×10^{4}
</td><td>
1
1
1
1

1

1
</td><td>
Extended response question

M1 Calculates (four) values of $\frac{1}{T}$
M2 Calculates (four) values of ln k
M3 Plots points on graph
M4 Draws line of best fit

Stage 2 can only be accessed if Table 4 has been completed correctly and a straight line graph is drawn.

Correct answer with or without working scores M5 and M6
</td></tr>
</table>

9.1 Continued	**Stage 3: Calculates E_a:** **M7** (recognises that gradient = -2.88×10^4 α $\frac{-Eact}{R}$) $E_a = 2.88 \times 10^4 \times 8.314$) **M8** (÷1,000 =) E_a = 239 kJ mol^{-1}	 1 1	**Stage 3** can only be accessed if the student has correctly calculated a gradient from their line graph. Correct answer with or without working scores M7 and M8 Answer to correct number of significant figure (3 sf)