Mark Scheme (Results)

Summer 2018

Pearson Edexcel GCE Chemistry
In Chemistry (9CH0) Paper 02
Advanced Organic Physical Chemistry

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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.

he 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.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Acceptable Answer	Mark
1(a)	The only correct answer is **D** ***A*** *is incorrect because it is not an addition reaction* ***B*** *is incorrect because no multiple bond is formed* ***C*** *is incorrect because initiation is only the first stage in the mechanism of the reaction*	**(1)**

Question Number	Acceptable Answer	Mark
1(b)	The only correct answer is **A** ***B*** *is incorrect because oxides of nitrogen are not black solids* ***C*** *is incorrect because oxides of sulfur are not black* ***D*** *is incorrect because unburnt hydrocarbons are not black solids*	**(1)**

Question Number	Acceptable Answer	Mark
1(c)	The only correct answer is **D** ***A*** *is incorrect because no alkenes are produced* ***B*** *is incorrect because hydrogen is formed* ***C*** *is incorrect because the molecular formulae of the organic compounds are not the same*	**(1)**

Question Number	Acceptable Answer	Mark
1(d)	The only correct answer is **C** ***A*** *is incorrect because* there are not 22 hydrogen atoms ***B*** *is incorrect because* there are not 20 hydrogen atoms ***D*** *is incorrect because* there are not 16 hydrogen atoms	**(1)**

(Total for Question 1 = 4 marks)

Question Number	Acceptable Answer	Mark
2(a)	The only correct answer is **C** ***A*** *is incorrect because gaseous reactants attach only to the surface* ***B*** *is incorrect because this happens after adsorption* ***D*** *is incorrect because this is detachment of the products from the surface*	**(1)**

Question Number	Acceptable Answer	Additional guidance	Mark
2(b)	An explanation that makes reference to the following: • increase surface (area) / more active sites **(1)** • (honeycomb structure) allows gases to flow through (the exhaust) **(1)**	Do not award a**B**sorption Ignore reference to rate of reaction / remove pollutants Do not award if comments are made that refer to the structure acting like a filter for the particulates or other substances	**(2)**

(Total for Question 2 = 3 marks)

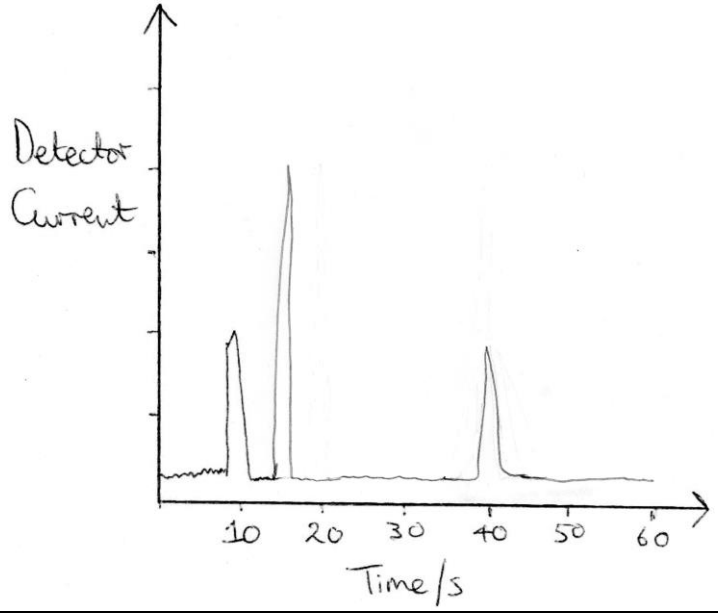
Question Number	Acceptable Answer	Additional guidance	Mark
3(a)(i)	• Answer to 2 SF	Example of calculation: R_f= 1.5 = 0.15 10 Allow 0.14 – 0.16 Do not award 3SF, e.g. 0.140/0.150/0.160 Do not award an answer with units	**(1)**

Question Number	Acceptable Answer	Additional guidance	Mark
3(a)(ii)	An answer that makes reference to the following: • serine **(1)** • methionine **(1)** • (reason) one amino acid is present twice (in the tripeptide) OR Another amino acid has the same R_f value as either serine or methionine **(1)**	 Allow for 1 mark out of the first two for F and B Allow 'there are two serine amino acids/ there are two methionine amino acids' Do not award if given with any other amino acid stated in the question Ignore reference to another amino acid not given in the table	**(3)**

Question Number	Acceptable Answer	Additional guidance	Mark
3(a)(iii)	An answer that makes reference to the following: • amino acids have different solubility / adsorption to the stationary phase **(1)** • amino acids have different solubility in the mobile phase **(1)**	Allow reverse arguments Do not award react with the stationary phase Allow "TLC plate" for stationary phase Allow interact with/affinity for/form different intermolecular forces with the stationary or mobile phase Allow "solvent" for mobile phase Ignore references to molecular mass/size	**(2)**

Question Number	Answer	Mark
3(a)(iv)	The only correct answer is **C** ***A*** *is incorrect because* this is a test for starch ***B*** *is incorrect because* this is a strong acid-weak base indicator ***D*** *is incorrect because* this is a weak acid-strong base indicator	**(1)**

Question Number	Acceptable Answer	Additional guidance	Mark
3(b)(i)	A statement that makes reference to • gases are inert / do not react (with the components of the mixture)	Ignore references to intermolecular bonding / stability Do not award for not an oxidising agent	**(1)**

Question Number	Acceptable Answer	Additional guidance	Mark
3(b)(ii)	A sketch that includes • peak at 15 seconds and 40 seconds **(1)** • (peak at 15 seconds) with height at approximately twice that of the peak at 10 seconds **(1)** • (peak at 40 seconds with) height at approximately the same height as that of the peak at 10 seconds **(1)** Exemplar sketch  	Penalise additional peaks Max 1 for the differences in height if both peaks are not at correct positions	**(3)**

(Total for Question 3 = 11 marks)

Question Number	Acceptable Answer	Additional guidance	Mark
4(a)(i)	correct equation	Example of equation: $2NaN_3 \rightarrow 2Na + 3N_2$ Allow multiples Ignore state symbols even if incorrect	**(1)**

Question Number	Acceptable Answer	Additional guidance	Mark
4(a)(ii)	• conversion of volume and temperature to correct units **(1)** • rearrangement of ideal gas equation so $n=pV \div RT$ and calculation of $n(N_2)$ in moles **(1)** • evaluation of $n(NaN_3)$ **(1)** • answer converted into mass to 2/3 SF **(1)** Allow TE at each stage	Example of calculation: 67 dm^3 = 0.067 m^3, 300°C = 573 K $n(N_2) = \frac{140\,000 \times 0.067}{8.31 \times 573}$ = = 1.9699…..(mol) $n(NaN_3)$ = (2/3 x 1.9699…..=) 1.313…. (mol) m= (1.313 …. x 65 = 85.3629..=) = 85.4 / 85 (g) Correct answer without working scores (4)	**(4)**

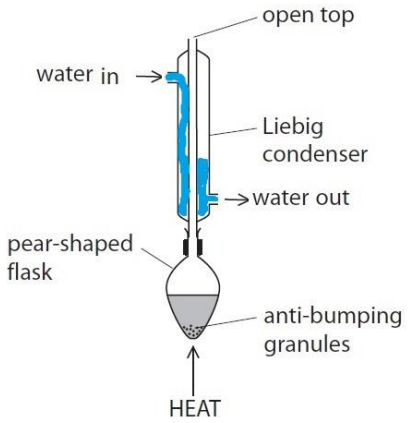
Question Number	Acceptable Answer	Additional guidance	Mark
4(b)	An answer that makes reference to the following points: • Nitrogen (is reduced) from +5 to 0 **(1)** • Sodium (is oxidised) from 0 to +1 **(1)** • Balanced equation **(1)**	Look for oxidation numbers annotated on the equation Do not award potassium oxidised Penalise omission of "+" sign, once only Example of balanced equation: **10**Na +**2**$KNO_3 \rightarrow K_2O$+ **5**Na_2O + N_2 Allow multiples	**(3)**

Question Number	Acceptable Answer	Additional guidance	Mark
4(c)	An answer that makes reference to the following points: • Neutralisation reaction / acid base reaction **(1)** • Sodium and/or potassium oxides are caustic / corrosive **(1)** • Salts (silicates) formed are inert / unreactive **(1)**	 Allow salt formation Allow "metal oxides" Ignore "harmful" / "alkaline" Allow "not harmful"/ "not caustic" Ignore "neutral"	**(3)**

Question Number	Acceptable Answer	Mark
4(d)	The only correct answer is **A** ***B*** *is incorrect because the peak would shift to the left and be higher* ***C*** *is incorrect because the peak would shift to the left not to the right* ***D*** *is incorrect because the peak would be shift to the left not to the right*	**(1)**

(Total for Question 4 = 12 marks)

Question Number	Acceptable Answer	Additional guidance	Mark
5(a)	• Balanced equation **(1)** • Appropriate colours **(1)**	Example of equation: $Cr_2O_7^{2-} + \mathbf{14}H^+ + \mathbf{6}e^- \rightarrow \mathbf{2}Cr^{3+} + \mathbf{7}H_2O$ Allow multiples Orange colourless green colourless Allow 'No colour' for colourless Do not award 'blue' for 'green' Do not award 'clear' for colourless Do not award if any spaces left blank Ignore any colour given for electrons Ignore any shades of colour	**(2)**

Question Number	Acceptable Answer	Additional guidance	Mark
5(b)(i)	A diagram with any shading that is not 100%	An example of a suitable diagram:  Allow shaded area to show 'air pockets'	**(1)**

Question Number	Acceptable Answer	Additional guidance	Mark
5(b)(ii)	An answer that makes reference to the following prevention of uncontrolled boiling by: • distributing the heat more evenly **or** • providing a surface for bubbles to form/allow smaller bubbles to form/provides nucleation sites for bubbles	 Do not award provide surface area for reaction Ignore reference to mixing the reagents/provide smooth boiling	**(1)**

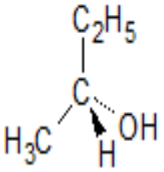
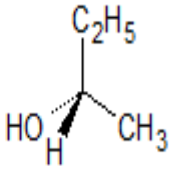
Question Number	Acceptable Answer	Mark
5(c)	The only correct answer is **B** ***A*** *is incorrect because not a systematic name* ***C*** *is incorrect because it has five carbons* ***D*** *is incorrect because it has only three carbons*	**(1)**

Question Number	Acceptable Answer	Additional guidance	Mark
5(d)	An explanation that makes reference to the following • ethanol would be oxidised to ethanal **(1)** • because ethanal has a low boiling temperature **or** ethanal will distil before ethanoic acid can be formed **(1)**	Allow aldehyde for ethanal Allow ethanal will be formed Allow ethanal is (more) volatile Accept reverse argument in terms of reflux condensing ethanal for oxidation to ethanoic acid	**(2)**

(Total for Question 5 = 7 marks)

Question Number	Acceptable Answer	Additional guidance	Mark
6(a)	An answer that gives reference to the following • **(M1)** use of ethanol (as a solvent) **(1)** • **(M2)** use of silver nitrate (solution) **(1)** • **(M3)** equal amounts used of each halogenoalkane **(1)** • **(M4)** measure the time taken for precipitate to form **(1)** • **(M5)** use a water bath (to control a raised temperature) **(1)**	Allow "alcohol" Do not award ammoniacal silver nitrate Ignore use of nitric acid Allow equal volumes/equal stated volumes Allow "time for cross to disappear" Do not award for a colour to form. M4 dependent on M2 or near miss. If hydroxide (ions) used for hydrolysis then measuring the reaction is too quick, so no M4. The solution would need to be acidified before the addition of silver nitrate if M2 is to be awarded. If hydrochloric acid is used, then only M1, M3 and M5 can be scored	**(5)**

Question Number	Acceptable Answer	Additional guidance	Mark
6(b)	An explanation that makes reference to the following • the reaction rate is in the order 1-chlorobutane<1-bromobutane<1-iodobutane **(1)** • because the C-Cl bond is stronger than the C-Br bond which is stronger than the C-I bond **(1)**	Accept reverse arguments Incorrect trend scores (0) Allow 'the C-Cl bond is the strongest' Ignore any reasoning given Do not award if reference is made to the bonding of the halide (ion)	**(2)**

Question Number	Acceptable Answer	Additional guidance	Mark
6(c)	 (1)  (1) Forms (two) isomers which are non-superimposable **(1)**	Diagram must be 3-dimensional, i.e. include 'wedges'. Allow Br instead of OH Ignore attachment of –OH, CH_3 and C_2H_5 groups Standalone mark Allow a chiral carbon has **four** different groups attached (so they are non-superimposable) Do not award has four different 'molecules' attached	**(3)**

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>6(d)</td><td>
This question assesses the student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.

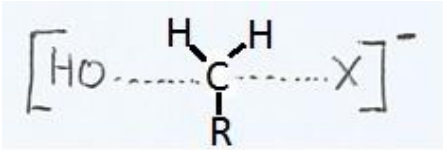
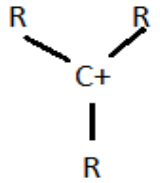
Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.
<table>
<tr><td>Number of indicative marking points seen in answer</td><td>Number of marks awarded for indicative marking points</td></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
<table>
<tr><td></td><td>Number of marks awarded for structure of answer and sustained lines of reasoning</td></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:
The mark for indicative content should be added to the mark for lines of reasoning. For example, a response with four 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).
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 zero marks for linkages).

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.

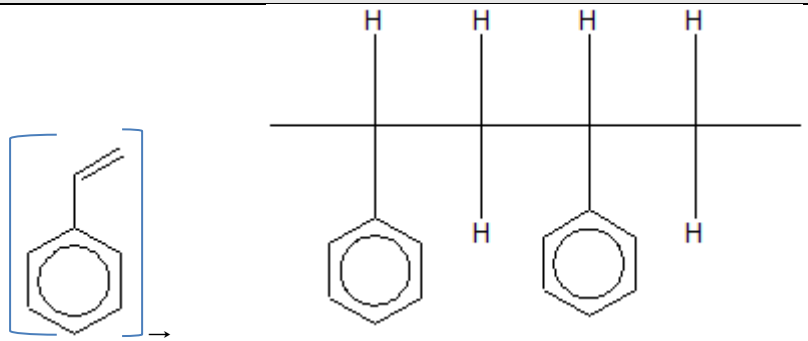
If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).
</td><td>(6)</td></tr>
</table>

	Indicative content	More than one indicative marking point may be made within the same comment or explanation	
	• (similarity)(both) are nucleophilic substitution **(1)**	Words needed at least once provided S_N1 and S_N2 are given	
	• Hydrolysis mechanism for RCH_2X/primary is S_N2 via a transition state **and** R_3CX/tertiary is S_N1 via a carbocation/intermediate **(1)**		
	• RCH_2X and OH^- in the RDS **(1)**	Allow "both/two species in the RDS"	
	• R_3CX only in the RDS **(1)**	Allow correct rate equations for IP3 and IP4	
	• (RCH_2X forms a transition state with OH^-) diagram, including dotted lines and charge **(1)**	 Allow "-" either on the "OH" or the "X" Ignore point of attachment of OH Ignore dipoles within structure	
	• (R_3CX forms a carbocation / intermediate) diagram, including charge **(1)**	 Ignore shape Ignore references to comparative rates of reaction between 1° and 3° even if incorrect Ignore references to optical activity.	

(Total for Question 6 = 16 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
7(a)	An answer that makes reference to the following: synthetic pathway that consists of: (Step 1) • (acylation of benzene) using ethanoyl chloride **(1)** • use of aluminium chloride (and heat) **(1)** (Step 2) • (reduction of) **A** with $LiAlH_4$ in ether (dry) **(1)** (Step 3) • (dehydration of) **B** with (conc.) phosphoric acid/H_3PO_4 **(1)** (Intermediates) • identification of **A** as phenylethanone and **B** as (1-)phenylethanol  **(1)**	The compounds used can be stated or given within equations. Only award if part of a Friedel-Crafts reaction Only award if given to reduce an aromatic carbonyl or carboxylic acid Allow (conc.) sulfuric acid/ H_2SO_4 Only award if given to dehydrate an aromatic alcohol Accept formulae for names, but if both given, then both must be correct This also applies to reagents Do not award use of other reagents not in the table.	**(5)**

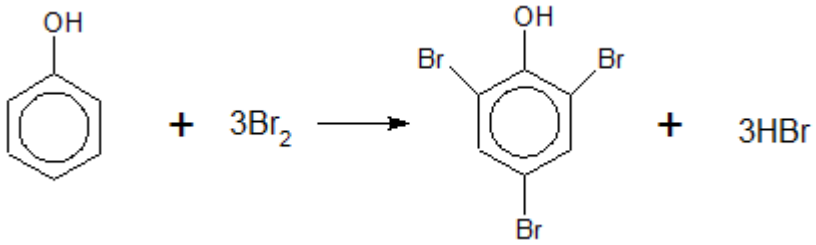
Question Number	Acceptable Answer	Mark
7(b)	The only correct answer is **B** ***A*** *is incorrect because this is an oxidising agent for alcohols not alkenes* ***C*** *is incorrect because this would not react* ***D*** *is incorrect because this would only produce an alcohol*	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
7(c)		Accept skeletal, structural or displayed formulae Accept any orientation of benzene ring Ignore brackets Ignore 'n' / '2n' / '$^{n}/_{2}$' Allow syndiotactic and atactic forms Allow more than two units, as long as all correct. Neither of these diagrams scores Both have missing CH_2 	**(1)**

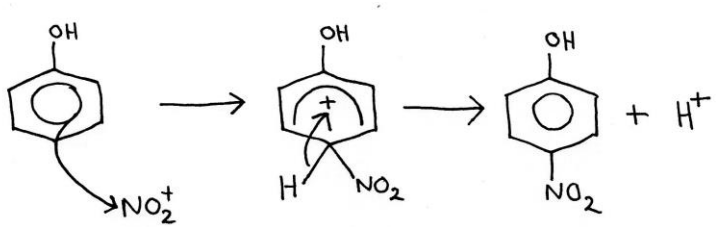
Question Number	Acceptable Answer	Additional Guidance	Mark
7(d)	An answer that makes reference to the following: An advantage • release of energy/avoids landfill **(1)** A disadvantage • release of toxic fumes (of polycyclic aromatics) **(1)**	Allow used to generate electricity Allow Release of benzene/carbon monoxide Release of carbon dioxide because of global warming / it's a greenhouse gas/ reduces recycling Release of carbon particulates increases respiratory problems Do not award damages the ozone layer Do not award references to acid rain Ignore just 'harmful' fumes	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
7(e)	• calculation of M_r of phenylethene **(1)** • answer converted into percentage to 2 or 3 SF **(1)**	<u>Example of calculation</u>: (M_r of phenylethene = 104 % = (96 ÷ 104 x 100 = 92.30769..%) =92 (%)/92.3 (%) Allow TE on incorrect M_r as long as answer not >100% Correct answer without working scores (2)	**(2)**

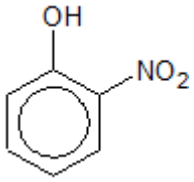
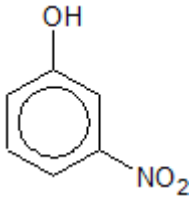
(Total for Question 7 = 11 marks)

Question Number		Additional Guidance	Mark
8(a)(i)	 • Structure of 2,4,6-tribromophenol **(1)** • Balanced equation **(1)**	Ignore state symbols even if incorrect Do not award $C_6H_3OBr_3$ M2 dependent on M1	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
8(a)(ii)	An answer that makes reference to the following: Similarity • Both electrophilic substitution **(1)** Any two from: Contrast • No need of a halogen carrier with phenol **(1)** • oxygen's lone pair of electrons interacts with the benzene ring of delocalised electrons so electrophilic attack more likely **(1)** • Tri-substitution of phenol compared to mono for benzene **(1)** • Bromination of phenol requires bromine in aqueous solution but benzene requires liquid bromine **(1)** • Bromination of phenol requires room temperature but benzene requires heating (under reflux) / reflux **(1)**	Ignore comments of ease of reaction Should be stated clearly as a similarity Accept reverse argument Allow $Fe/FeBr_3/AlBr_3$ with benzene Do not award just 'catalyst' Allow reference to OH group Allow 'bromine' for 'electrophilic' Do not award for nucleophilic attack Allow "multiple-" for "tri-"	**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
8(b)(i)	An answer that makes reference to • Electron pair movement from ring to electrophile **(1)** • Formula of intermediate ion **(1)** • Curly arrow from C-H bond to reform delocalised ring and correct final structure with H^+ also formed **(1)**	Allow arrow that starts from anywhere within the hexagon but it must go to the nitrogen of the ion 'Horseshoe' to cover at least three carbon atoms, facing the tetrahedral carbon and part of the + sign to be inside the 'horseshoe' Do not award '+' charge on the tetrahedral carbon Do not award dotted bonds unless part of a 3D structure Curly arrow to go from the bond to anywhere inside the ring Accept the drawing of HSO_4^- to remove the H from the ring as long as H_2SO_4 is given as the product instead of H^+ Exemplar mechanism  Do not penalise attachment of OH/NO_2 to benzene ring Penalise incorrect product: 1 mark	**(3)**

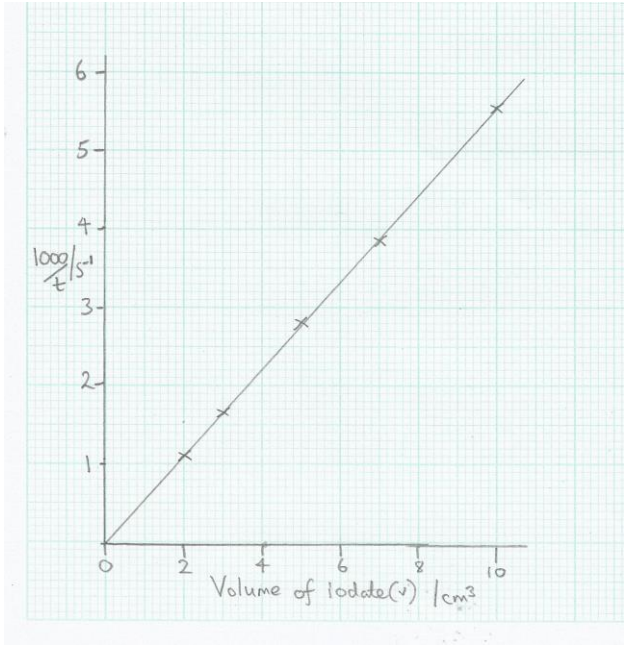
Question Number	Acceptable Answer	Mark
8(b)(ii)	The only correct answer is **B** ***A*** *is incorrect because this is 15% of the mass of the starting material* ***C*** *is incorrect because this is the percentage of the starting mass over the max mass of product* ***D*** *is incorrect because this is 100% yield and not 15%*	**(1)**

Question Number		Additional Guidance	Mark
8(b)(iii)	 **and** 	Ignore connectivity of OH/NO_2	**(1)**

(Total for Question 8 = 10 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
9(a)	A statement that makes reference to the following: • The chance of five or more ions colliding in the rate determining step is negligible	 Allow 'at the same time' for the RDS	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
9(b)(i)	A statement that makes reference to the following: • So that the volume of iodate(V) ions is proportional to the concentration.	 Allow the volume of iodate(V) ions can be used instead of the concentration in plotting the graph. Ignore reference to "fair tests".	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
9(b)(ii)	• calculation of all three 1000/t values **(1)** • axes: correct way round, labelled and including units **(1)** • suitable scale **(1)** • all points plotted correctly, with best-fit straight line through the origin **(1)**	(5.56) 3.85, 2.80, 1.65, (1.11) Do not award 2.8 or ≥3SF Do not award use of T for t Plotted points must cover at least ½ the graph paper on each axis Allow ±½ square Ignore plotting of experiment 6 Exemplar graph  	**(4)**

Question Number	Acceptable Answer	Additional Guidance	Mark
9(b)(iii)	An answer that makes reference to the following: • first order (with respect to iodate(V) ions) **(1)** • because straight line goes through the origin / rate is (directly) proportional to concentration **(1)**	Mark independently Allow "volume" for "concentration" Do not award references of proportionality to time Ignore references to half life	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
9(c)(i)	• value of rate constant to 2 or 3 SF **(1)** • units of rate constant **(1)**	<u>Example of calculation:</u> (Rate=k[H_2O_2][I^-] so k= rate ÷ ([H_2O_2][I^-]) =$1.24\times10^{-3}\div(1.50\times10^{-3}\times2.10\times10^{-3})$ =393.65…) = 390/394 $dm^3\ mol^{-1}\ s^{-1}$ Accept units in any order No TE on incorrect rate equation	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
9(c)(ii)	An explanation that makes reference to • starch is an indicator (to react with the iodine) **(1)** • the time taken for the formation of the blue-black complex (can be used to calculate the reaction rate) **(1)**	Do not award references to iodide/I^- Allow Reacts with iodine/produces a blue-black colour when the reaction is complete. Allow Changes colour when all the thiosulfate is used up. Allow indication of 'time taken'	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
9(d)(i)	• calculation of gradient of straight line **(1)** • numerical value of E_a **(1)** • sign and units **(1)**	<u>Example of calculation</u> Gradient = −19500 Allow ±500 $-E_a$ = −19500 x 8.31 / 1000 = 162 ± 5 + **and** kJ mol^{-1} Accept +162000 **$Jmol^{-1}$** Final answer with or without working scores (3) Allow TE for incorrect gradient as long as the final value is not negative Ignore SF except 1SF	**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
9(d)(ii)	An answer that makes reference to the following: • (Reason) anomalous point	Allow description of Allow 'outlier'	**(1)**

(Total for Question 9 = 16 marks)