How Fast? - Rates
Mark Scheme 2

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Rates, Equilibria & Further Organic Chemistry
Sub Topic	How Fast? - Rates
Booklet	Mark Scheme 2

Time Allowed: **39 minutes**

Score: **/32**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

Question Number	Acceptable Answers	Reject	Mark
1(a)(i)	use a colorimeter/colorimetry **OR** (quench the mixture with sodium hydrogencarbonate and) titrate with (sodium) thiosulfate solution **(1)** to monitor the (concentration of) iodine **Conditional** on first mark **(1)** **ALLOW** titrate with silver nitrate solution **and** to monitor the (concentration of) iodide ions **(1)** **ALLOW** measure the electrical conductivity **and** to monitor the (concentration of) H^+/I^- ions **(1)**	iodine 'clock' reaction dilatometer pH	**(2)**

Question Number	Acceptable Answers	Mark
1(a)(ii)	rders CH_3COCH_3 first order I_2 zero order H^+ first order all 3 correct **(2)** any 2 correct **(1)** **Explanations** CH_3COCH_3 –(initial) rate is (directly) proportional to $[CH_3COCH_3]$ / graph is straight line through the origin /increases linearly **AND** H^+ - (initial) rate is (directly) proportional to $[H^+]$/ graph is straight line through the origin /increases linearly **ALLOW** as $[CH_3COCH_3]$ doubles the rate doubles **and** as $[H^+]$ doubles the rate doubles **(1)** **IGNORE** gradient is constant **IGNORE** explanation linked to half life I_2 – (initial) rate does not change (as $[I_2]$ changes)/ graph is a horizontal line/ (initial) rate is independent of $[I_2]$ /line has zero gradient **(1)** **IGNORE** line has no gradient	**(4)**

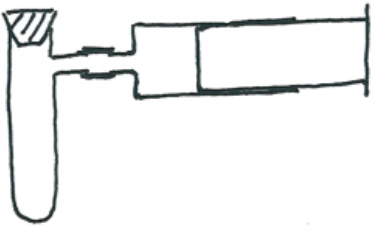| Question Number	Acceptable Answers	Reject	Mark
1(a)(iii)	rate = k [CH$_3$COCH$_3$] [H$^+$] **ALLOW** rate = k [CH$_3$COCH$_3$]^1 [H$^+$]^1[I$_2$]^0 R/r for rate **Consequential** on their orders in **(a)(ii)** **IGNORE** K for k **IGNORE** state symbols, even if incorrect	rate equation = no mention of rate =	**(1)**

Question Number	Acceptable Answers	Reject	Mark
1(a)(iv)	$k = \dfrac{8.80 \times 10^{-6}}{0.667 \times 0.667}$ $= 1.978 \times 10^{-5}$ **(1)** units dm^3 mol^{-1} s^{-1} **(1)** **ALLOW** units in any order **Both marks must be consequential** on their rate equation **IGNORE** SF except 1SF	incorrect rounding eg 1.97×10^{-5}	**(2)**

Question Number	Acceptable Answers	Reject	Mark
1(a)(v)	irst mark (CH$_3$)$_2$CO + H$^+$ → (CH$_3$)$_2$C$^+$OH **(1)** **ALLOW** [(CH$_3$)$_2$COH]$^+$/(CH$_3$)$_2$COH$^+$ /(CH$_3$)$_2$CO$^+$H **Second mark** (the rate-determining step) involves the species in the rate equation **OR** only propanone and H$^+$ ions are in the rate equation **OR** iodine is not in the rate equation so does not take part in (or before) the rds **OR** iodine is zero order so does not take part in (or before) the rds **(1)** **IGNORE** just 'reaction shown is consistent with rate equation' **Both marks consequential** on their rate equation	Any formula where H is not joined to O eg CH$_3$COCH$_4$$^+$	**(2)**

Question Number	Acceptable Answers	Reject	Mark
1(b)(i)	gradient = -19 600 K value **(1)** sign and units **(1)** **ALLOW** -18 600 to -20 600 Marks are stand alone **IGNORE** SF		**(2)**

Question Number	Acceptable Answers	Mark
1(b)(ii)	E_a = -8.31 x gradient = (+)163000 J mol^{-1} /(+)163 kJ mol^{-1} **ALLOW** (+)155000 to 171000 J mol^{-1} / 155 to 171 kJ mol^{-1} **ALLOW** TE from (b)(i) value (do not allow mark if value is negative) **(1)** value to 3sf and correct unit **(1)**	**(2)**

(Total for Question 1 = 15 marks)

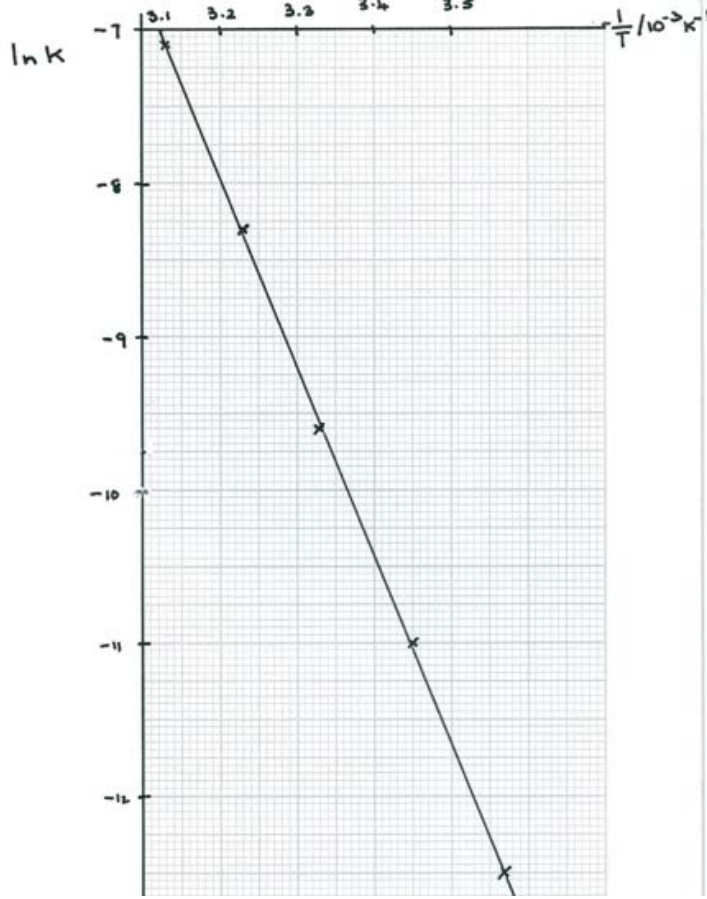| Question Number	Acceptable Answers	Reject	Mark
2(a)	 **Method 1 – gas collection** **Diagram 2 marks** stoppered/ sealed side arm test tube/ stoppered/ sealed test tube with delivery tube/ stoppered/ sealed side arm flask/ stoppered/ sealed flask with delivery tube **(1)** gas syringe **OR** collection of gas over water in a measuring cylinder/ upturned burette/ graduated gas tube **(1)** **IGNORE** heat **Measurements** **volume** of gas **and** time **(1)** **Method 2 – mass loss** **Diagram 2 marks** digital balance **(1)** flask with cotton wool/ mineral wool in neck **OR** open flask/ beaker **(1)** **Measurements** mass (loss) **and** time **(1)** **Method 3 – colour change** **Diagram 2 marks** colorimeter **(1)** light and filter shown **(1)** **Measurements** transmission/ absorbance **and** time **(1)**	amount of gas	3

Question Number	Acceptable Answers	Reject	Mark
2(b)(i)	s^{-1} **ALLOW** 1/s sec^{-1} any actual unit of time to power -1	$time^{-1}$ t^{-1}	**1**

Question Number	Acceptable Answers	Reject	Mark
2(b)*(ii)	**First mark** 1st Step – slow 2nd Step – fast 3rd Step – fast **(1)** **Second mark – stand alone** the slow(est)/ first step is the rate determining step **(1)** **Third mark – consequential on correct first mark** (1 mol) N_2O_5 is in the rate equation so the reaction with N_2O_5 is the slow/ rate determining step **OR** only the species in the rate equation is in the first/ slow/ rate determining step **ALLOW** (there is only 1 mol of) one species/ N_2O_5 in the first/ slow/ rate determining step **(1)** **ALLOW** 1st Step – fast 2nd Step – slow 3rd Step – fast **(1)** the slow(est) step/second step is the rate determining step **(1)** there is only (1 mol of) one species in the steps up to and including the rate determining step **(1)**		**3**

Question Number	Acceptable Answers	Reject	Mark
2(c)(i)	(thermostatically controlled) water bath/ ice bath **ALLOW** oil bath	direct heating with flame electrical heater	**1**

Question Number	Acceptable Answers		Reject	Mark
2(c)(ii)	(1/T) 3.13 x 10^{-3}/ 3.125 x 10^{-3}	**(1)**	3.12 x 10^{-3}	
	(ln$k$) −7.1/ −7.05/ -7.0528	**(1)**	-7.0	**2**

Question Number	Acceptable Answers	Mark
2(c) ***(iii)**	**Graph – 3 marks** **First mark** axes correct with sensible scales i.e. points/line covering at least 3 large squares on the x axis and 5 on the y axis, with ln*k* values becoming more negative down the axis and the negative signs shown **(1)** **Second mark** both axes labelled, with units on x axis and no units on y axis x axis: 3.1-3.5 1/T /10^{-3}K^{-1} **OR** 3.1-3.5 1/Tx10^{3}/K^{-1} **OR** 0.0031-0.0035 **OR** 3.1 x 10^{-3}-3.5 x 10^{-3} 1/T /K^{-1} **ALLOW** x axis labels at bottom of page **(1)** **Third mark** points correctly plotted and straight line drawn **(1)**	

| | **Gradient – 2 marks – this may be shown on the graph**
gradient = -11550 to -12760 (K)

negative sign **(1)**
value (ignore sf) **(1)**

maximum 1 mark if an incorrect unit is given

ALLOW these marks if the correct sign and value for the gradient are shown in the calculation for E_a

Calculation - 2 marks

If E_a = (+)96.0 to (+)106 kJ mol^{-1} or (+)96000 to (+)106000 J mol^{-1}, award 2 marks
If E_a is in this range but is not given to 3 sf, or the units are incorrect or missing, award 1 mark

If not,
$E_a = -8.31$ x their gradient
OR
gradient $= -E_a/R$ **(1)**

value to 3 sf **and** units **and** consequential sign if negative **(1)**

ALLOW
correct answer to 3 sf, in range, **with sign and units**, but no working for gradient or E_a **(3)** | **7** |

<div align="center">Total for Question 2 = 17 marks</div>