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A' Level Chemistry

Year 2

Unit 12: Rates & Equilibrium

Summer Examination Revision Pack

The questions in this pack should be attempted **AFTER** completing all other revision.

Grade Accelerator

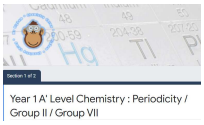
Recall Definitions
Drawing Diagrams
Using Equations
Drawing Graphs

Quizlet Classes

Flashcard Based
Games
Tests & Quizzes
Keyword Spell Checker

Condensed Notes

Keywords & Definitions
Key Concepts
Application
Key Skills



Online Forms

Take Time to Answer
Use Paper & Calculator
Work It Out
Review Missed Marks

Use the 3 Wave Process when completing these revision packs.

1. Complete the questions without assistance
(Can't answer a question? Leave it and move on)
2. Use your notes to fill any gaps after step 1
3. Use the mark scheme to fill in any remaining gaps.

1. Having gaps after step 1 is normal, that's why we are doing revision!
2. If your notes don't help during step 2, they are not good enough!
(Change your note taking method and try to understand the problem)
3. If you don't understand why the mark scheme answer is correct, **see Andy.**

If you struggle with the questions in the pack, **STOP!** and complete some more revision.

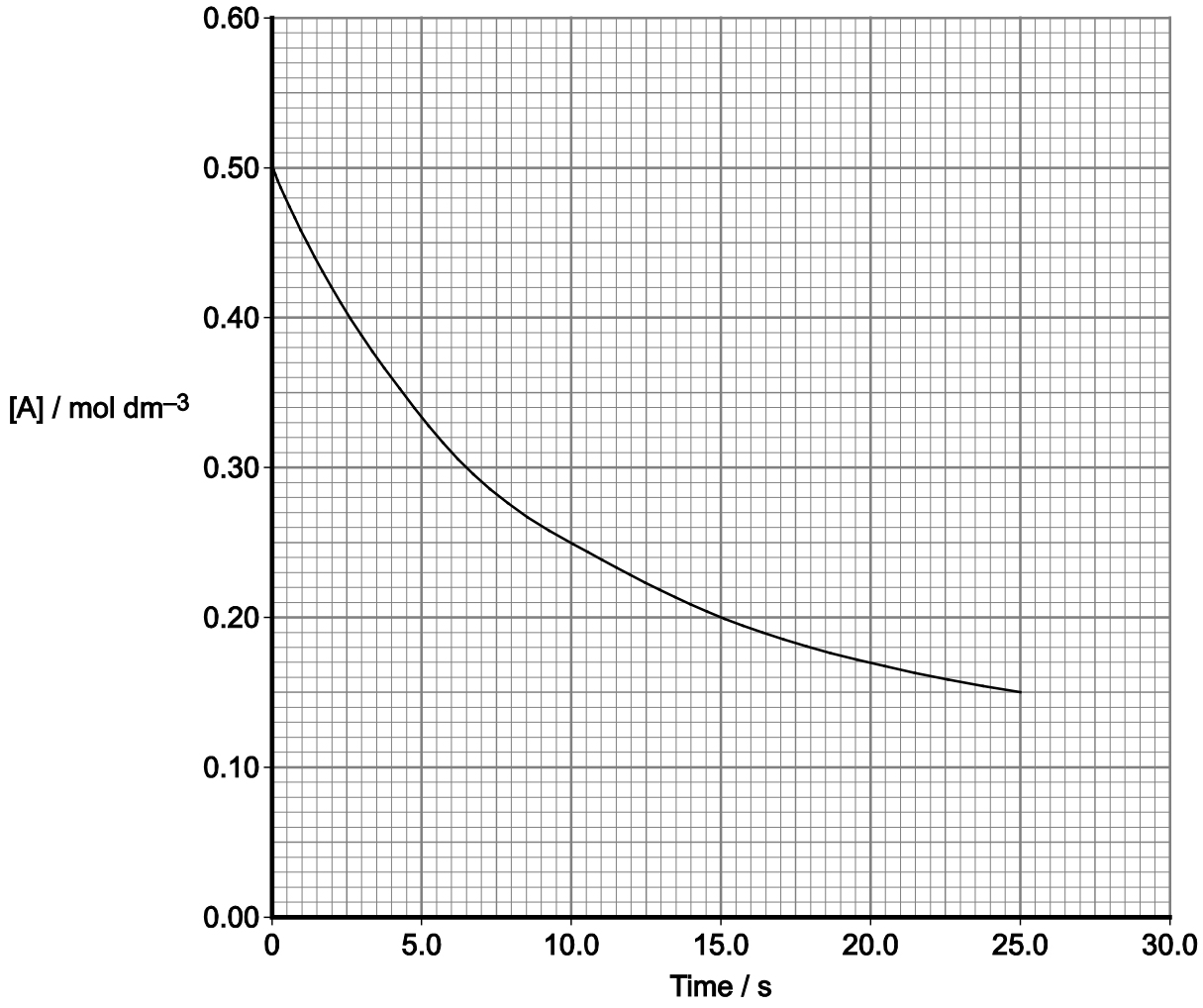
If you come to a complete dead-end, **STOP!** and speak to **Andy** asap.

0 2 The rate equation for the reaction between compounds **A** and **B** is

$$rate = k[\mathbf{A}]^2[\mathbf{B}]$$

Figure 2 shows how, in an experiment, the concentration of **A** changes with time, *t*, in this reaction.

Figure 2



0 2 . 1 Draw a tangent to the curve at $t = 0$

[1 mark]

0 2 . 2 Use this tangent to deduce the initial rate of the reaction.

[1 mark]

Initial rate _____ mol $dm^{-3}s^{-1}$

0 2 . 3 The experiment was repeated at the same temperature and with the same initial concentration of **B** but with a different initial concentration of **A**.
The new initial rate was 1.7 times greater than in the original experiment.

Calculate the new initial concentration of **A**.

[2 marks]

Initial concentration of **A** _____ mol dm^{-3}

4

Turn over for the next question

Question	Answers	Mark	Additional Comments/Guidance
02.1	Straight line through (0.00, 0.50) which cuts time axis at between 5 and 12.5 secs OR conc 0.3 at time between 2s and 5s	1	If 'tangent' does not touch 0.5 mol dm^{-3} then CE=0 for 2.1 and 2.2. no tangent scores 0 in 2.1 and 2.2.
02.2	Mark is for correct calculation of their gradient : e.g. 0.50/11 = 0.045 or 4.5×10^{-2} (mol dm^{-3} s^{-1})	1	If 'tangent' does not touch 0.5 mol dm^{-3} then CE=0 for 2.1 and 2.2 Ignore negative sign (Expect a value between 0.04 and 0.1
02.3	[A] increases by $\sqrt{1.7}$ new[A] = 1.30×0.50 = 0.65 (mol dm^{-3}) 2 sfs min new$[A]^2$ = $1.7 \times (0.50)^2$ = 0.425 New [A] = 0.65 (mol dm^{-3}) 2 sfs min	2	Award 2 for 0.65 Award 1 mark for an AE using a correct method If candidate use their rate then CE=0 0.85 scores 1 if $\sqrt{}$ shown
Total		**4**	

0 3 A series of experiments is carried out with compounds **C** and **D**. Using the data obtained, the rate equation for the reaction between the two compounds is deduced to be

$$rate = k[\mathbf{C}][\mathbf{D}]$$

In one experiment at 25 °C, the initial rate of reaction is 3.1×10^{-3} mol dm^{-3} s^{-1} when the initial concentration of **C** is 0.48 mol dm^{-3} and the initial concentration of **D** is 0.23 mol dm^{-3}

0 3 . 1 Calculate a value for the rate constant at this temperature and give its units.

[3 marks]

Rate constant _____ Units _____

Question	Answers	Mark	Additional Comments/Guidance
03.1	k = (rate/[C][D]) =) $\frac{3.1\times10^{-3}}{(0.48)\times(0.23)}$	1	Mark is for insertion of numbers into correctly rearranged rate equation
	= 2.8×10^{-2} min 2sfs	1	
	$mol^{-1}\ dm^3\ s^{-1}$	1	Mark units separately in any order.

0 5 Bromate(V) ions and bromide ions react in acid conditions according to the equation

$$BrO_3^-(aq) + 5Br^-(aq) + 6H^+(aq) \rightarrow 3Br_2(aq) + 3H_2O(l)$$

0 5 . 1 A series of experiments was carried out at a given temperature. The results were used to deduce the rate equation for the reaction.

$$rate = k\,[BrO_3^-][Br^-][H^+]^2$$

Table 2 shows an incomplete set of results.

Table 2

Experiment	Initial $[BrO_3^-]$ / mol dm^{-3}	Initial $[Br^-]$ / mol dm^{-3}	Initial $[H^+]$ / mol dm^{-3}	Initial rate of reaction / mol dm^{-3} s^{-1}
1	0.10	0.20	0.30	2.4×10^{-2}
2		0.20	0.30	3.6×10^{-2}
3	0.20	0.40	0.50	
4	0.10	0.10		2.7×10^{-2}

Use the data from Experiment **1** to calculate a value for the rate constant, *k*, at this temperature and give its units.

Give your answer to an appropriate number of significant figures.

[3 marks]

k _____ Units _____

0 5 . 2 Complete **Table 2**.

[3 marks]

Space for working

Question 5 continues on the next page

Question	Answers	Mark	Additional Comments/Guidance
05.1	$k = \frac{2.4 \times 10^{-2}}{0.10 \times 0.20 \times (0.30)^2}$ (= 13.333) = 13 (must be 2 sfs) Units $\underline{mol^{-3}\ dm^{+9}\ s^{-1}}$	1 1 1	Mark is for insertion of numbers into a correctly re-arranged equation. Can be in any order
05.2 Marked with 5.1	Experiment 2 $[BrO_3^-]$ = 0.15 Experiment 3 rate = 0.26 or 0.27 Experiment 4 $[H^+]$ = 0.45 or 0.46	1 1 1	If k wrong in 5.1 : allow the expected answer OR values conseq to their k (allow mix & match) Ex 2 $[BrO_3^-]$ = 2/k Ext 3 rate = 0.02 × k Ex 4 $[H^+]$ = square root of (2.7/k)
Total			14

Do not write outside the box

0 4 Substances **P** and **Q** react in solution at a constant temperature.
The initial rate of reaction was studied in three experiments by measuring the change in concentration of **P** over the first five seconds of the reaction.
The data obtained are shown in **Table 1**.

Table 1

Experiment	Time after mixing / s	Concentration / mol dm^{-3}	
		P	**Q**
1	0	1.00×10^{-2}	1.25×10^{-2}
	5.0	0.92×10^{-2}	not measured
2	0	2.00×10^{-2}	1.25×10^{-2}
	5.0	1.84×10^{-2}	not measured
3	0	0.50×10^{-2}	2.50×10^{-2}
	5.0	0.34×10^{-2}	not measured

0 4 . 1 Complete **Table 2** to show the initial rate of reaction of **P** in each experiment.

[1 mark]

Table 2

Experiment	Initial rate / mol dm^{-3} s^{-1}
1	1.6×10^{-4}
2	
3	

Do not write outside the box

0 4 . 2 Determine the order of reaction with respect to **P** and the order of reaction with respect to **Q**.

[2 marks]

Order with respect to **P** _____

Order with respect to **Q** _____

0 4 . 3 A reaction between substances **R** and **S** was second order with respect to **R** and second order with respect to **S**.
At a given temperature, the initial rate of reaction was 1.20×10^{-3} mol dm^{-3} s^{-1} when the initial concentration of **R** was 1.00×10^{-2} mol dm^{-3} and the initial concentration of **S** was 2.45×10^{-2} mol dm^{-3}

Calculate a value for the rate constant, *k*, for the reaction at this temperature.
Give the units for *k*

[3 marks]

k _____ Units _____

6

Question	Answers	Additional Comments/Guidelines	Mark
04.1	Expt 2 3.2×10^{-4} Expt 3 3.2×10^{-4}	Both needed	1
04.2	**P** order = 1 **Q** order = 2	These answers only, not consequential on 4.1 Allow if 4.1 blank.	1 1
04.3	(Rate = $k[R]^2[S]^2$) k = Rate/$[R]^2[S]^2$ **OR** $1.20 \times 10^{-3}/(1.00 \times 10^{-2})^2(2.45 \times 10^{-2})^2$ k = 19992 = 2.00×10^4 Units $mol^{-3}\ dm^9\ s^{-1}$	M1 for rearrangement M2 for answer (Allow 1.99×10^4) Allow conseq units for their expression in M1	M1 M2 M3

Do not write outside the box

Answer **all** questions in the spaces provided.

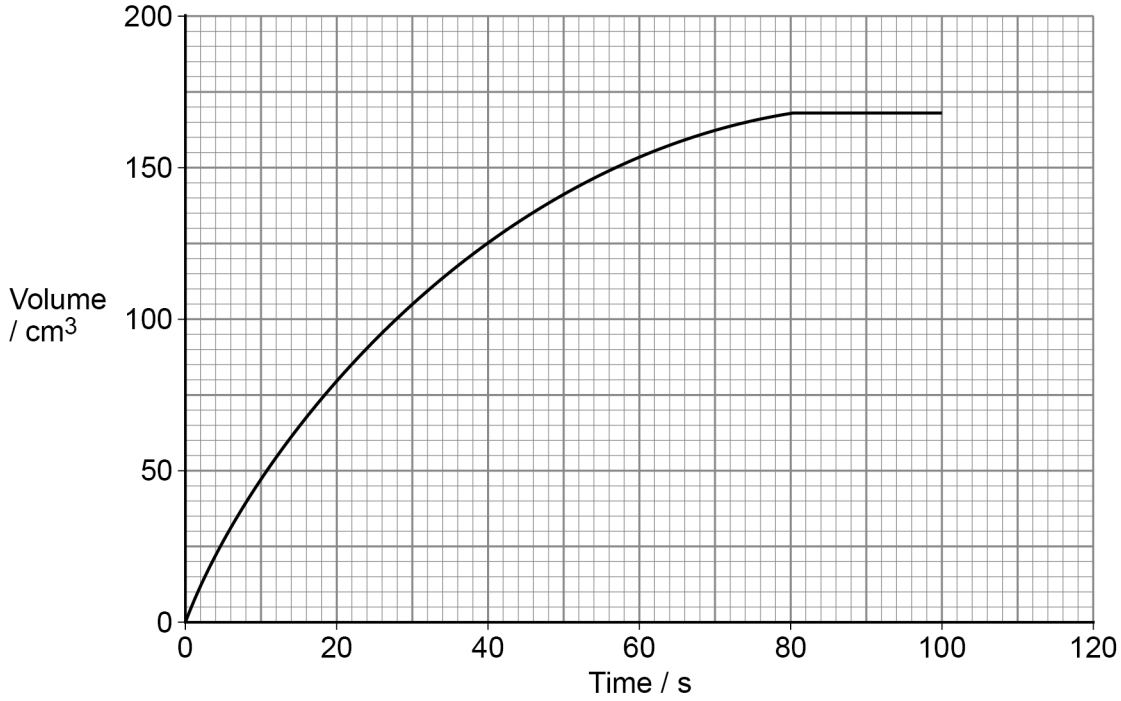
0 1 This question is about rates of reaction.

Phosphinate ions ($H_2PO_2^-$) react with hydroxide ions to produce hydrogen gas as shown.

$$H_2PO_2^- + OH^- \rightarrow HPO_3^{2-} + H_2$$

A student completed an experiment to determine the initial rate of this reaction.
The student used a solution containing phosphinate ions and measured the volume of hydrogen gas collected every 20 seconds at a constant temperature.
Figure 1 shows a graph of the student's results.

Figure 1



0 1 . 1 Use the graph in **Figure 1** to determine the initial rate of reaction for this experiment. State its units. Show your working on the graph.

[3 marks]

Rate _____ Units _____

Do not write outside the box

0 1 . 2 Another student reacted different initial concentrations of phosphinate ions with an excess of hydroxide ions. The student measured the time (*t*) taken to collect 15 cm^3 of hydrogen gas. Each experiment was carried out at the same temperature. **Table 1** shows the results.

Table 1

Initial $[H_2PO_2^-]$ / mol dm^{-3}	*t* / s
0.25	64
0.35	32
0.50	16
1.00	4

State the relationship between the initial concentration of phosphinate and time (*t*).

Deduce the order of the reaction with respect to phosphinate.

[2 marks]

Relationship _____

Order _____

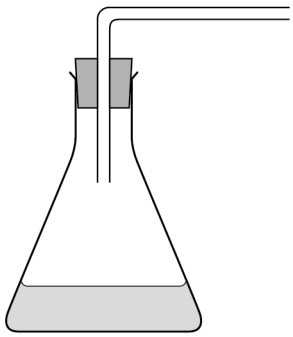
Question 1 continues on the next page

Do not write outside the box

0 1 . 3 Complete the diagram in **Figure 2** to show how the hydrogen gas could be collected and measured in the experiments in Questions **01.1** and **01.2**.

[1 mark]

Figure 2



The rate equation for a different reaction is

$$rate = k\,[L]\,[M]^2$$

0 1 . 4 Deduce the overall effect on the rate of reaction when the concentrations of both **L** and **M** are halved.

[1 mark]

Do not write outside the box

0 1 . 5 The rate of reaction is 0.0250 mol dm^{-3} s^{-1} when the concentration of **L** is 0.0155 mol dm^{-3}

Calculate the concentration of **M** if the rate constant is 21.3 mol^{-2} dm^6 s^{-1}

[3 marks]

Concentration of **M** _____ mol dm^{-3}

0 1 . 6 Define the term overall order of reaction.

[1 mark]

_____

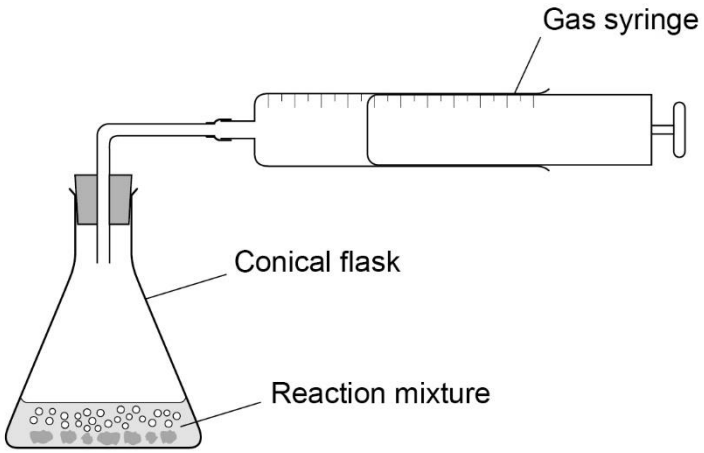
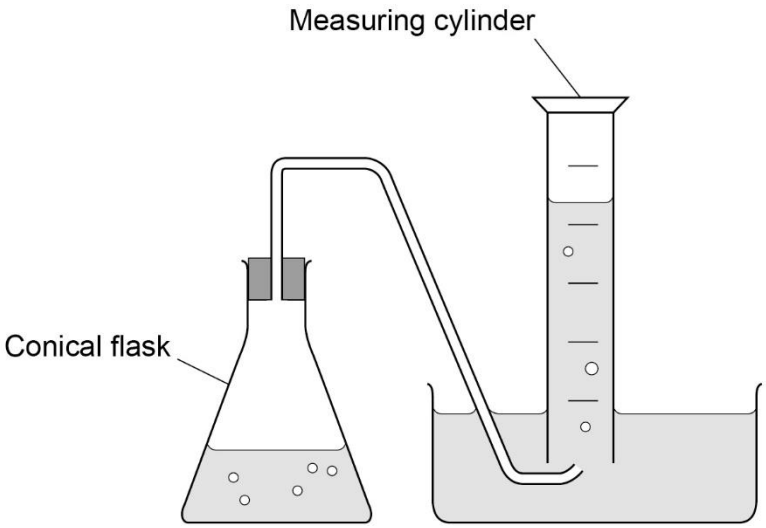
_____

_____

11

Turn over for the next question

Question	Answers	Additional comments/Guidelines	Mark
01.1	**M1** tangent drawn to the curve at 0,0	If tangent not drawn at 0,0 then allow conseq gradient calculation	1 1
	M2 Evidence of value used in calculation leading to initial rate = 5.5	Note allow 5 – 7	1
	M3 $cm^3\ s^{-1}$	NOT cm^3 / s	
01.2	**M1** $[H_2PO_2^-]^2 \propto 1/t$	Accept time argument eg if conc doubled time is quartered Accept suitable words that implies a square or square root relationship	1
	M2 Order = 2	Not simple description of as conc increases time decreases	1

01.3	 Either gas syringe or measuring cylinder over water	 Tubing shown should not be closed Syringe should have a plunger shown Allow lack of graduations	1

01.4	Falls by a factor of 8 OR Multiplied by $^{1}/_{8}$ OR Divided by 8	Allow halved then quartered / Decreases by 2^3	1

01.5	**M1** $[M]^2 = \frac{Rate}{k\,[L]}$ **M2** $[M]^2 = \frac{0.0250}{21.3 \times 0.0155}$ $(=7.57 \times 10^{-2})$ **M3** $[M] = \sqrt{7.57 \times 10^{-2}} = 0.275$ mol dm^{-3} (min 2 sf)	Re-arrangement Inserts correct numbers into their rearranged expression Takes square root (allow ecf for square root of their M2) Common error is to use 0.25 rather than 0.025. This leads to an answer of 0.870. Scores 2 Upside-down expression leads to an answer of 3.63. Scores 2	1 1 1
01.6	The sum of powers/indices (to which the concentrations are raised in the rate equation)	All the orders added/ sum of the (individual) orders This can be explained using a general rate equation stated as an example e.g. Rate = $k[A]^x[B]^y$ and the overall order is x + y	1

Do not write outside the box

1 0 This question is about rates of reaction.
Iodine and propanone react together in an acid-catalysed reaction

$$CH_3COCH_3(aq) + I_2(aq) \rightarrow CH_3COCH_2I(aq) + HI(aq)$$

A student completed a series of experiments to determine the order of reaction with respect to iodine.

Method
- Transfer 25 cm^3 of 1.0 mol dm^{-3} propanone solution into a conical flask.
- Add 10 cm^3 of 1.0 mol dm^{-3} HCl(aq)
- Add 25 cm^3 of 5.0×10^{-3} mol dm^{-3} $I_2(aq)$ and start a timer.
- At intervals of 1 minute, remove a 1.0 cm^3 sample of the mixture and add each sample to a separate beaker containing an excess of $NaHCO_3(aq)$
- Titrate the contents of each beaker with a standard solution of sodium thiosulfate and record the volume of sodium thiosulfate used.

1 0 . 1 Suggest why the 1.0 cm^3 portions of the reaction mixture are added to an excess of $NaHCO_3$ solution.

[2 marks]

1 0 . 2 Suggest why the order of this reaction with respect to propanone can be ignored in this experiment.

[2 marks]

Question 10 continues on the next page

Do not write outside the box

The volume of sodium thiosulfate solution used in each titration is proportional to the concentration of iodine in each beaker.

Table 5 shows the results of the experiment.

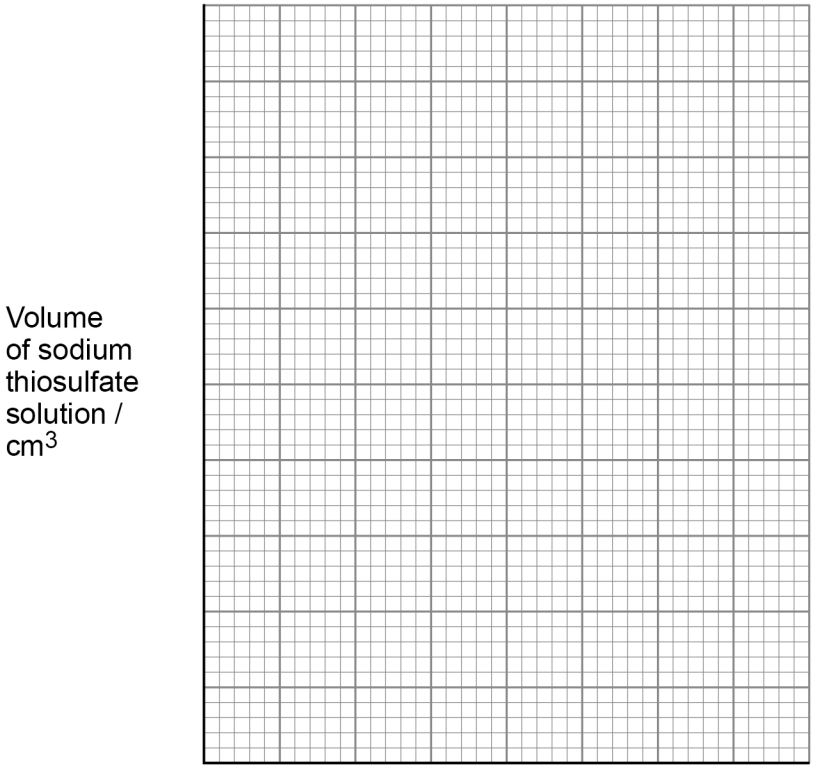
Table 5

Time / minutes	Volume of sodium thiosulfate solution / cm^3
1	41
2	35
3	24
4	22
5	16
6	10

1 0 . 3 Use the results in **Table 5** to draw a graph of volume of sodium thiosulfate solution against time.

Draw a line of best fit.

[3 marks]



Do not write outside the box

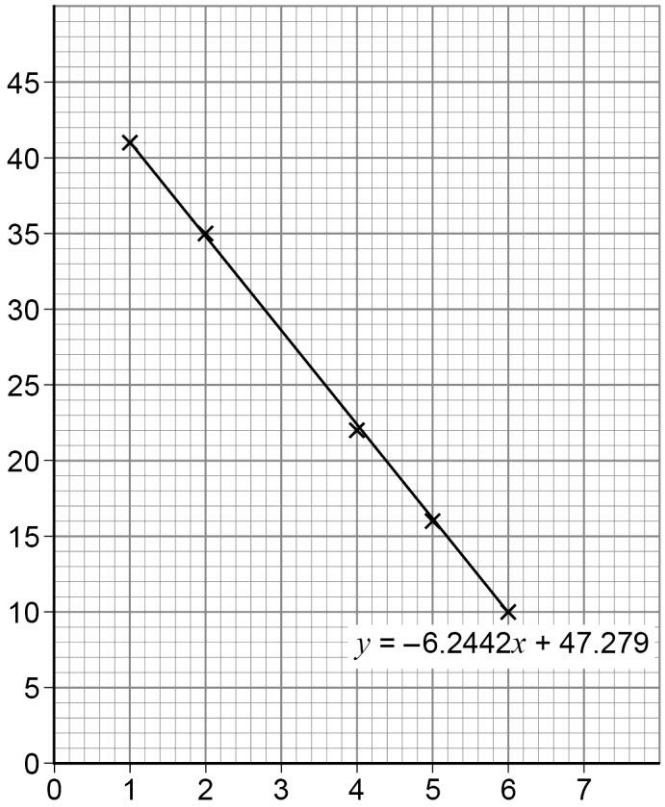
1 0 . 4 Explain how the graph shows that the reaction is zero-order with respect to iodine in the reaction between propanone and iodine.

[2 marks]

Question 10 continues on the next page

Question	Answers	Additional Comments/Guidelines	Mark
10.1	The sodium hydrogencarbonate solution neutralises the acid (catalyst) So stops the reaction		M1 M2

Question	Answers	Additional Comments/Guidelines	Mark
10.2	The concentration/amount of propanone is much larger than/200 times larger than the concentration/amount of iodine <u>Concentration</u> of propanone is (almost) constant	The change in concentration in propanone is negligible	M1 M2

Question	Answers	Additional Comments/Guidelines	Mark
10.3	 Suitable axes (plotted points must take up at least half of the grid) For all points correctly plotted to ± $^1/_2$ small square For straight line of best fit which avoids the anomalous plot		M1 M2 M3

Question	Answers	Additional Comments/Guidelines	Mark
10.4	The graph is a straight line / has a constant gradient So the rate of reaction does not change as the concentration (of iodine) changes / the iodine is being used up at a constant rate.	Correct rate vs conc graph scores M2	M1 M2

Answer **all** questions in the spaces provided.

Do not write outside the box

0 1 An acidified solution of butanone reacts with iodine as shown.

$$CH_3CH_2COCH_3 + I_2 \rightarrow CH_3CH_2COCH_2I + HI$$

0 1 . 1 Draw the displayed formula for $CH_3CH_2COCH_2I$

Give the name of $CH_3CH_2COCH_2I$

[2 marks]

Displayed formula

Name _____

Do not write outside the box

0 1 . 2 The rate equation for the reaction is

$$rate = k[CH_3CH_2COCH_3][H^+]$$

Table 1 shows the initial concentrations used in an experiment.

Table 1

	$CH_3CH_2COCH_3$	I_2	H^+
Initial concentration / mol dm^{-3}	4.35	0.00500	0.825

The initial rate of reaction in this experiment is 1.45×10^{-4} mol dm^{-3} s^{-1}

Calculate the value of the rate constant, *k*, for the reaction and give its units.

[3 marks]

k _____

Units _____

0 1 . 3 Calculate the initial rate of reaction when all of the initial concentrations are halved.

[1 mark]

Initial rate of reaction _____ mol dm^{-3} s^{-1}

Question 1 continues on the next page

Do not write outside the box

0 1 . 4 An experiment was done to measure the time, *t*, taken for a solution of iodine to react completely when added to an excess of an acidified solution of butanone.

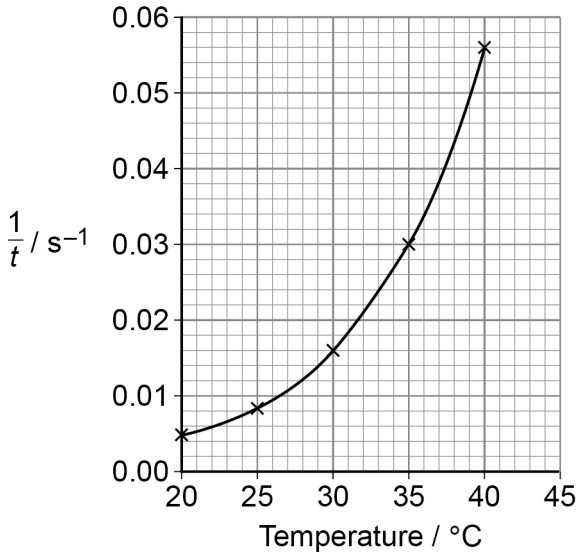
Suggest an observation used to judge when all the iodine had reacted.

[1 mark]

The experiment was repeated at different temperatures.

Figure 1 shows how $\frac{1}{t}$ varied with temperature for these experiments.

Figure 1



Do not write outside the box

0 1 . 5 Describe and explain the shape of the graph in **Figure 1**.

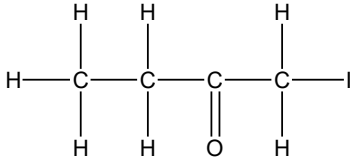
[3 marks]

0 1 . 6 Deduce the time taken for the reaction at 35 °C

[1 mark]

Time _____ s

Question 1 continues on the next page

Question	Answers	Additional Comments/Guidelines	Mark
01.1	 1-iodobutan(-2-)one	Apply list principle for more than one structure given Allow 1-iodo-2-butanone	M1 M2 (2 x AO1)

Question	Answers	Additional Comments/Guidelines	Mark
01.2	$\frac{\text{Rate}}{[CH_3CH_2COCH_3]\,[H^+]} = k$ $k = 4.(04) \times 10^{-5}$ or 0.00004(04) $mol^{-1}\ dm^3\ s^{-1}$	Rearranged expression Or with numbers If upside down = 24752 mol dm^{-3} s If multiply = 5.20 x 10^{-4} mol^3 dm^{-9} s^{-1}	M1 M2 M3 (3 x AO1)

Question	Answers	Additional Comments/Guidelines	Mark
01.3	$3.6(25) \times 10^{-5}$ (mol dm^{-3} s^{-1})	Allow 3.59 x 10^{-5} to 3.63 x 10^{-5}	1 (AO1)

Question	Answers	Additional Comments/Guidelines	Mark
01.4	Brown colour removed	Goes colourless Allow (orange) brown to colourless Allow purple to colourless	1 (AO3)

Question	Answers	Additional Comments/Guidelines	Mark
01.5	As T increases rate (1/t) increases OR time for completion decreases Exponentially OR By a greater/ increasing factor <u>Many</u> more particles have $E \geq E_a$	 Or rate increases more and more as temp increases i.e. description of exponential increase NOT just higher collision frequency NOT just more successful collisions	M1 M2 M3 (2 x AO1, 1 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
01.6	Time = $^{1}/_{0.03}$ = 33 s		1 (AO2)