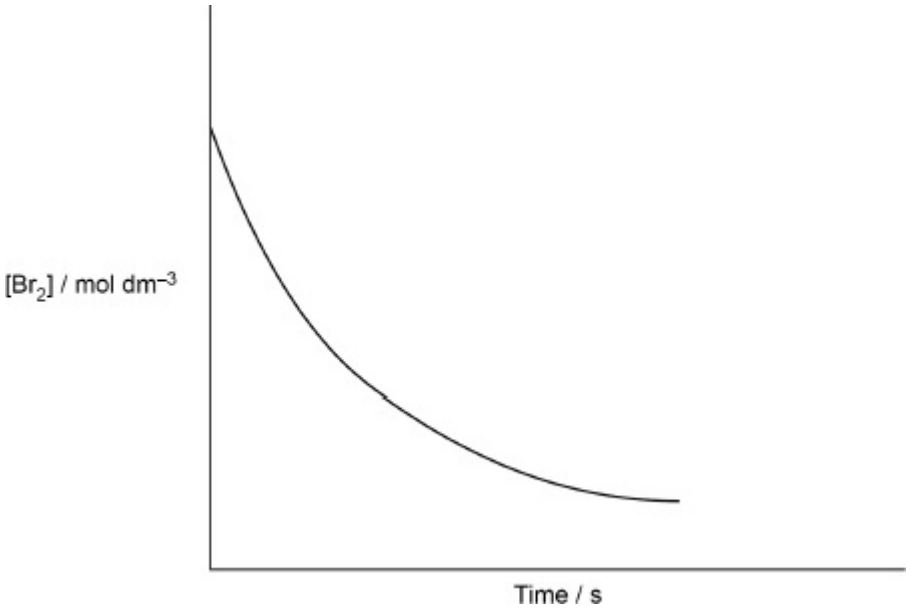
Mark schemes

Q1.

(a) Curve e.g.



Curve with decreasing gradient

1

(b) **M1** For $[OH^-] = 7.50 \times 10^{-2}$

M2 For rate = 2.75×10^{-11}

M3 $k = \frac{\text{rate}}{[CH_3COCH_3][OH^-]}$

M3 For rearranging rate equation

OR

$k = \frac{2.75 \times 10^{-11}}{(1.5 \times 10^{-2}) \times (2.5 \times 10^{-2})}$

For inserting correct numbers in rearranged equation

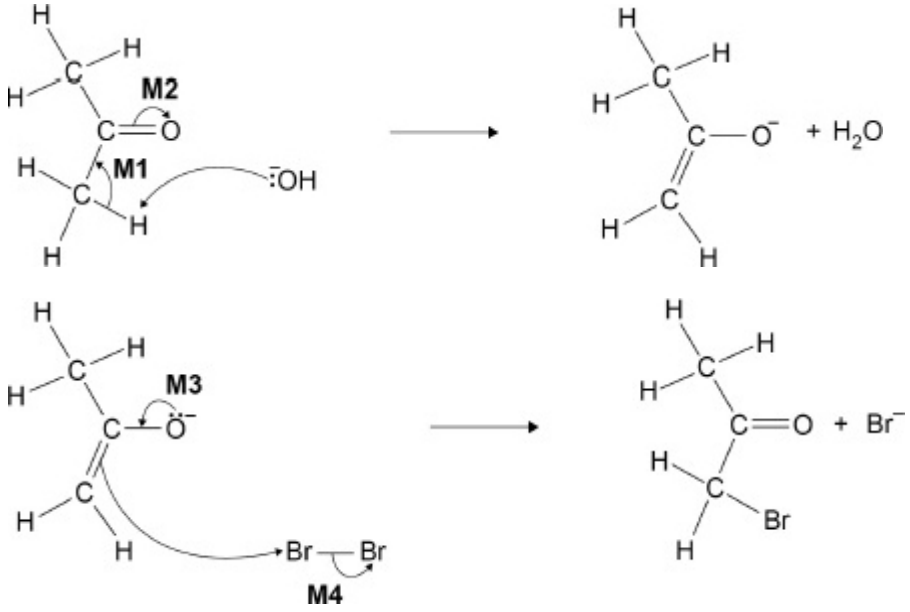
M4 k = 7.3(3) × 10^{-8}

M5 Units = $mol^{-1}dm^3s^{-1}$

If rearrangement upside down lose M3 but can score M4 for 1.36 × 10^7 as ECF
M5 for mol dm^{-3} s as ECF

5

(c)



M1 Arrow from C-H bond to C-C

M2 Arrow from C=O bond to O

M3 Arrow from lone pair on O to C-O bond

M4 Arrow from Br-Br bond to Br

Dipoles must be correct if shown for M4

4

(d) Step 1 includes CH_3COCH_3 <u>and</u> OH^- and these are also in the rate equation
OR
Step 1 contains all the species in the rate equation

Br_2 not in step 1 <u>and</u> not in rate equation so it has to be step 1

1

[11]

Q2.

(a) **M1** (Instead of leaving the flask open) to avoid acid/solution/liquid escaping
OR
to avoid (acid/solution/liquid) splashing/spraying/spitting (out).

Ignore evaporation/spilling/to let gas escape/to avoid loss of product/reactant/impurities getting in

M2 (Instead of inserting a bung) to allow gas/CO_2 to escape

Ignore pressure would build up

Ignore air

NOT other wrongly identified gas(es)

2

(b) So that surface area/mass/amount stays (approx./effectively) constant

Ignore concentration stays constant

Ignore volume

Ignore so HCl is the limiting factor

Ignore so rate is only affected by [HCl] (as in Q)

1

(c) **M1** m_t/mass of CO_2 produced in time t is proportional to the (amount/concentration of) HCl that has reacted (at time t)

M2 m_{total}/total mass of CO_2 produced is proportional to the total (amount/concentration of) HCl that has reacted/was present initially

(therefore $m_{total} - m_t$ is proportional to (amount/conc of) HCl present at time t)

Allow 'Equal to'/'represents' for proportional to

Allow m_{total} is proportional to HCl 'added'

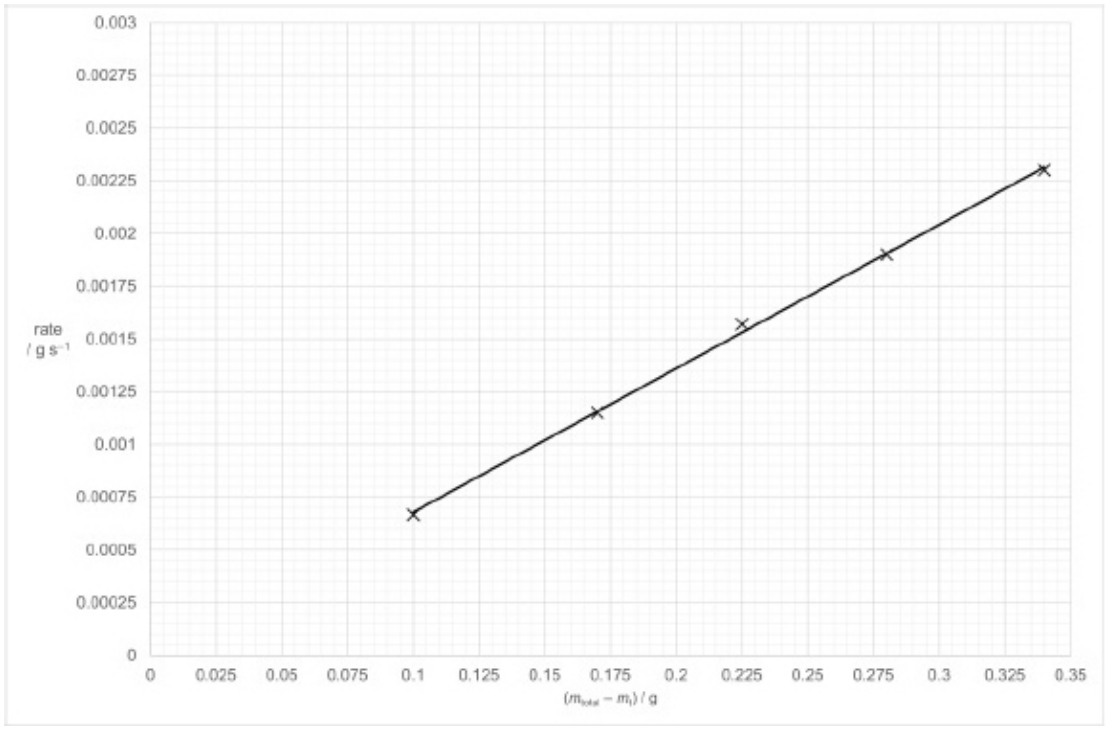
Alternative answer:

M1 $m_{total} - m_t$ is equal/proportional to (mass/amount of) CO_2 still to be produced

M2 (Mass/amount of) CO_2 still to be produced is proportional to (amount/concentration of) HCl still to react

2

(d)



M1 Scales designed so that plotted points (and origin if shown) occupy >50% along each axis **and** axes labelled including units

NOT if either/both scale reversed but allow ecf M2 and M3.

M2 Plotted points (all within half a small square)

M3 Suitable straight line (should be within one square of all points except potentially the middle one)

M3 ECF for best fit line (points above and below) from their plotted points

3

(e) Straight line **AND** through origin

Allow 'constant gradient' for straight line

Ignore (directly) proportional

1

(f) Any two from:

- Volume of gas / CO_2
- pH
- Concentration of HCl/acid/H^+
- Conductivity

NOT temperature

NOT 'volume' or 'concentration' unqualified

NOT time for $CaCO_3$ to 'dissolve'/disappear (as in excess)

Ignore mass loss

Ignore amount of CO_2

2

[11]

Q3.

(a) 1.75×10^{-3} AND -6.46

Allow 0.00175

NOT other sig figs (e.g. 1.7 x 10^{-3}, -6.5)

NOT 1.74 x 10^{-3}

1

(b) **M1** Unit of *k* (is s^{-1})

Mark independently

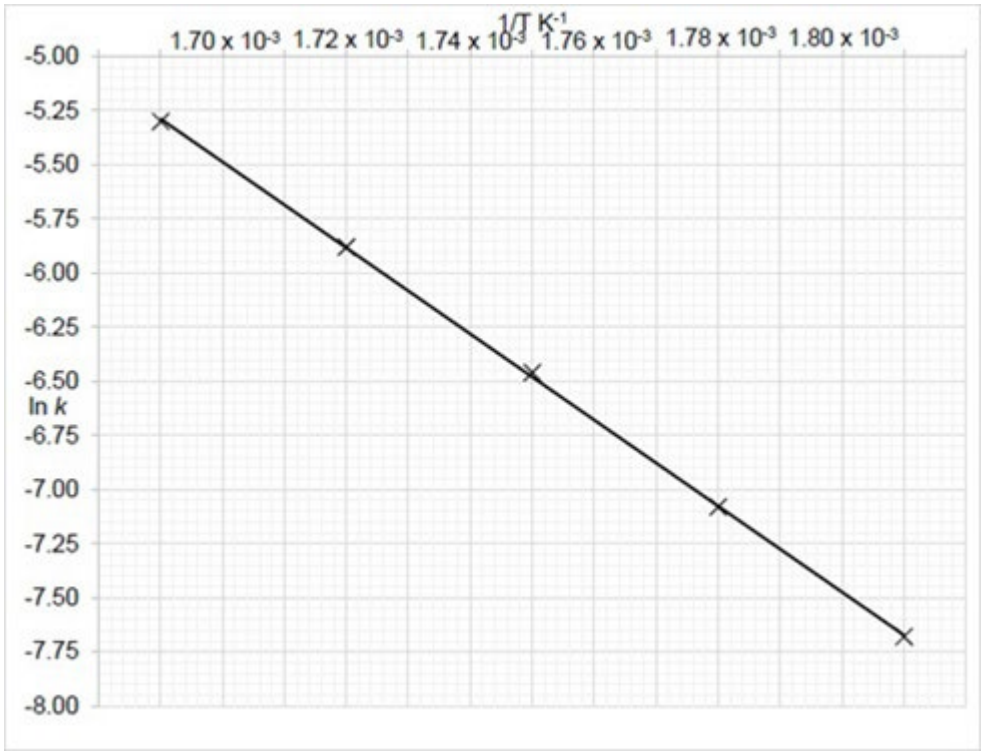
M1 Allow s^{-1} or k / s^{-1} or k in s^{-1}

NOT just k

M2 (Order) 1/first

2

(c)



M1 Points plotted (all within half a square) (ECF from (a) for 3rd point including if no values in the table)

M2 Best fit straight line (line within one square of each point) (best fit line - points above and below - based on their plotted points)

2

(d) **M1** Gradient (expected value = -19900)

Answer of (+)161 to (+)170 gets 3/3

Allow range from -19400 to -20400 from correct plotting and best fit line

ECF from any straight line

M2 $-\frac{E_a}{R}$ = gradient

can be implied by calculation shown e.g.
E_a = -M1 × 8.31 gets M2

M3 $E_a = \frac{-M1 \times 8.31}{1000}$ = (+)165 (kJ mol^{-1})

Allow negative E_a if positive gradient in M1

3

(e) **M1** (alkene) $CH_2{=}CHCH_3$

M2 (carbonyl) $(CH_3)_2CO$ / CH_3COCH_3

Allow any correct structural representations

C=C must be shown

Allow $C(CH_3)_2O$

If correct two structures are given but the wrong way round, then scores 1 mark

2

[10]

Q4.

(a) M1 Relative rate = 1.00

M2 [B] = 0.16

M3 Relative rate = 1.35

3

(b) M1 Step 2

M2 (By the end of step 2) 1 × H^+ and 2 × B have been used

Allow slowest step

2

[5]

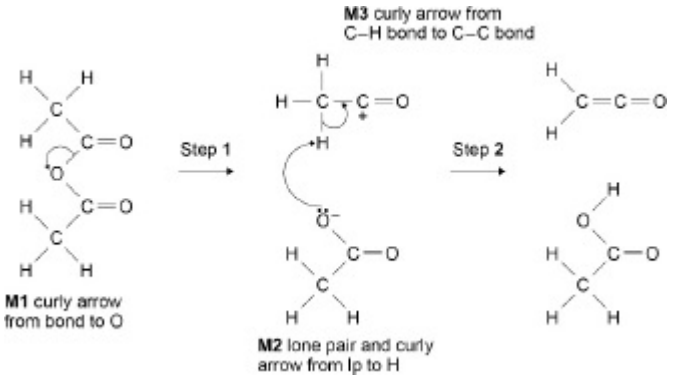
Q5.

(a) $C_nH_{2n-2}O$

Allow $C_nH_{2n}CO$ or $(CH_2)_nCO$ or $C_nH_{2(n-1)}O$

1

(b)



Allow other C-O bond breaking for M1

3

(c) M1 $\frac{k}{A} = e^{-Ea/RT}$

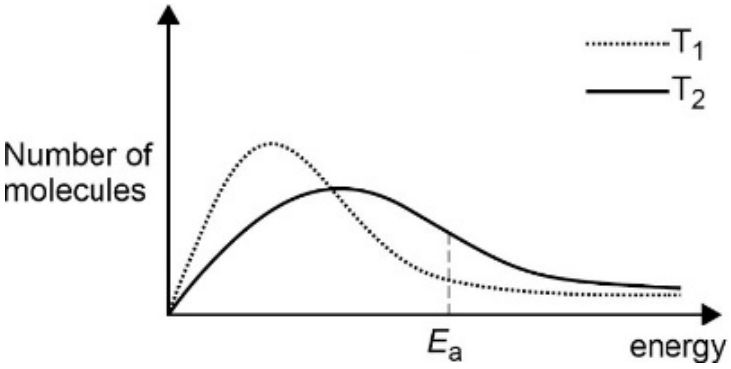
M2 $8.302 = \frac{34500}{8.31 \times T}$

M3 T = 500 K

OR via ln k = ln A - $\frac{Ea}{RT}$ or shown with numbers

3

(d)



M5 At T_2 (many) more particles have $E \geq E_a$

M1 x axis labelled correctly (kinetic not required)

AND y axis labelled correctly allow particles

M2 Ea labelled on x axis

M3 Distribution correct shape for T_1

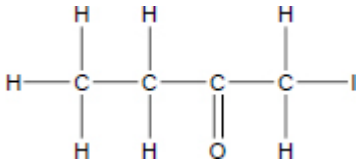
M4 Peak at T_2 lower with max shifted right and only crosses once

5

[12]

Q6.

(a)



Apply list principle for more than one structure given

M1

1-iodobutan-2-one

Allow 1-iodo-2-butanone

M2

(b) $\frac{\text{Rate}}{[CH_3CH_2COCH_3][H^+]} = k$

Rearranged expression Or with numbers

M1

k = 4.(04) × 10^{-5} or 0.00004(04)

If upside down = 24752 mol dm^{-3} s

If multiply = 5.20 × 10^{-4} mol^3 dm^{-9} s^-

M2

mol^{-1} dm^3 s^{-1}

M3

(c) 3.6(25) × 10^{-5} (mol dm^{-3} s^{-1})

Allow 3.59 × 10^{-5} to 3.63 × 10^{-5}

1

(d) Brown colour removed

Goes colourless

Allow (orange) brown to colourless

Allow purple to colourless

1

(e) As T increases rate ($1/t$) increases OR time for completion decreases

M1

Exponentially
OR
By a greater/ increasing factor

Or rate increases more and more as temp increases ie description of exponential increase

M2

Many more particles have $E \geq E_a$

NOT just higher collision frequency

NOT just more successful collisions

M3

(f) Time = $\frac{1}{0.03}$ = 33 s

1

(g) $\ln(1.55 \times 10^{-5}/1.70 \times 10^{-4}) = \frac{E_a}{R}\left(\frac{1}{333} - \frac{1}{303}\right)$

Insertion of correct values

M1

$-2.39 = \frac{E_a}{R}(-2.97 \times 10^{-4})$

Evaluate LHS and fraction on RHS

M2

$\frac{2.39 \times 8.31}{2.97 \times 10^{-4}} = E_a$

Re-arrange for E_a

M3

66937

Evaluate

M4

66.9 kJ mol^{-1}

convert to kJ mol^{-1}

M5

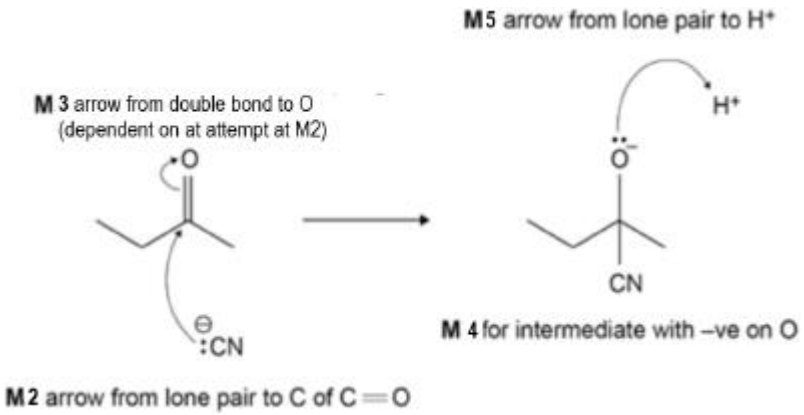
If only k_1 and k_2 reversed this gives a negative answer for E_a Lose M1 and M5

If AE in M2 allow ECF

Allow ECF from M4 to M5 for a correct unit conversion

Allow range 66.3 − 67.1

(h) Nucleophilic Addition



M1M2M3M4M5

ALLOW negative charge anywhere on cyanide

But attacking lone pair must be on C

Do not award M3 without attempt of M2

Allow M2 for attack to a positive carbon following breaking of C=O

Penalise covalent KCN in M2

M3 ignore partial charges unless wrong

Penalise M3 for incorrect connection between CN and C

NB Allow fully displayed or other structural formulae

[21]

Q7.

(a) **M1** High**er**/**est** concentration of / more H_2O_2 / particles / molecules / reactants

1

M2 More frequent successful collisions

1

Alternative approach

M1 *Low**er**/**est** concentration of / fewer particles / molecules / reactants as time goes on*

M2 *Less frequent successful collisions (look for both ideas even if separated)*

Ignore *'chance' / 'probability'*

(b) **M1** Suitable tangent drawn

M1 *Tangent must be drawn with ruler and touch line at 0.05 mol dm^{-3} (± 1 square) and not cross the curve (if white seen between lines it crosses)*

1

M2 **−**0.00120 to –0.00155 (mol dm^{-3} s^{-1})

M2 Ignore *units*

Allow *ecf from unsuitable tangent i.e if M1 not awarded*

Ignore *sign of gradient*

1

(c) **M1** $[H_2O_2]_{initial}$ = 0.083 mol dm^{-3}

Allow *0.082 − 0.084*

1

M2 $[H_2O_2]_t$ = 0.0664 (mol dm^{-3})

Allow *0.0656 − 0.0672 (scores 2/2)*

2SF minimum

Allow *ecf from* ***M1*** *(M2 = M1 × 0.8)*

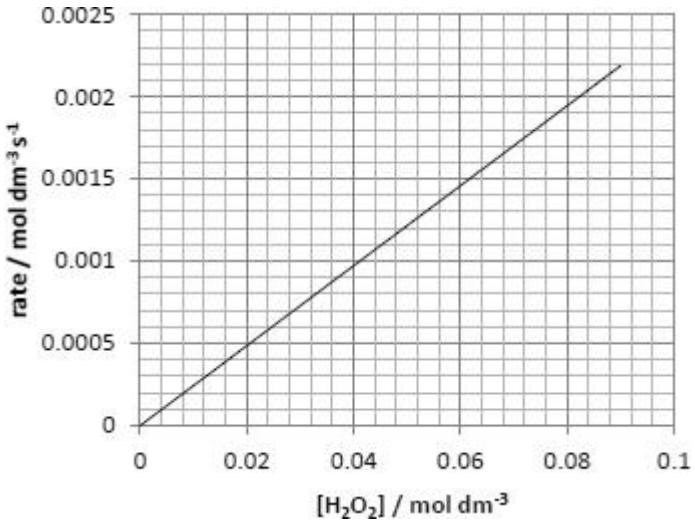
1

(d) **M1** Points plotted

M1 *allow each point (± 1/2 square)*

1

M2 best fit straight line drawn



M2 *line should be drawn with a ruler and cover the five points given going within 1 square of each point, no doubles no kinks. The line does not need to be extended to the origin*

Allow *reasonable best fit line if points plotted incorrectly*

1

(e) **M1** 1st order

1

M2 straight line graph through the origin

Ignore *rate is (directly) proportional to [H_2O_2]*

Allow *constant gradient line through the origin*

Allow *use of data from line to show e.g. x2 conc = x2 rate*

Allow *if M1 missing*

Not *if M1 wrong*

1

[10]