Chapter 22:Reaction kinetics

Homework marking scheme

1 **a** The HCl formed consists of H^+ and Cl^- ions in aqueous solution. [1]

As the reaction proceeds, the number of ions increases and so the conductivity increases. [1]

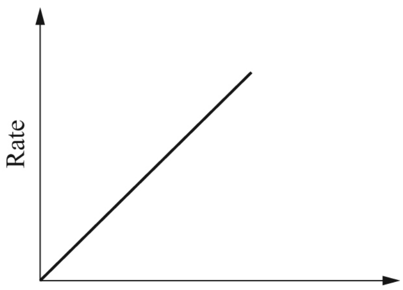
b **i** 2-chloro-2-methylpropane [1]

ii 2-methylpropan-2-ol [1]

c The first step is the rate-determining step because it involves just one molecule. [1]

Step two involves an ion and a molecule. [1]

d



correct scales on axes [1]

straight line going through origin. [1]

e **i** $CH_3CH_2CH_2CH_2Cl + OH^- \rightarrow CH_3CH_2CH_2CH_2OH + Cl^-$ [1]

ii second order [1]

iii rate = $k\,[CH_3CH_2CH_2CH_2Cl]\,[OH^-]$ [1]

iv The graph should have the vertical axis labelled as rate and the horizontal axis as time. [1]

The line starts at 32×10^{-3} and is a smooth curve. [1]

The time taken to go from 32 to 16 to 8 and then to 4, etc. should be a constant. [1]

f For $(CH_3)_2CClCH_3$ the intermediate carbonium iron is stabilised by the three electron-donating methyl groups. [1]

The $CH_3CH_2CH_2CH_2Cl$ has only one alkyl group stabilising the carbonium ion and therefore this route is not favoured. [1]

g **i** elimination [1]

ii $(CH_3)_2CClCH_3 + NaOH \rightarrow CH_3(CH_3)C{=}CH_2 + H_2O + NaCl$ [1]

2 **a** **i** P = OI^- [1]

$H_2O_2 + I^- \rightarrow H_2O + OI^-$ [1]

$H_2O_2 + OI^- \rightarrow H_2O + I^- + O_2$ [1]

ii the iodide ions are regenerated the end of step 2 [1]

iii rate = $k\,[H_2O_2]$ [1]

iv measure the volume of oxygen produced (at constant pressure) [1]

b **i** points plotted correctly [1]

smooth curve through points [1]

ii the half-life for the reaction is 75 s [1]

the half-life is constant and therefore the reaction is first order [1]

iii $k = \dfrac{0.693}{75} = 9.24 \times 10^{-3}\ s^{-1}$

take off 1 mark if the unit is incorrect [2]

c $2H_2O_2 \rightarrow 2H_2O + O_2$

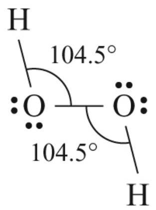
1 dm^3 of H_2O_2 would give 10 dm^3 of O_2 [1]

$N(H_2O_2) = 2 \times N(O_2) = 2 \times \frac{10}{24} = 0.833$ mol [1]

The second mark is for using the equation and for recognising that the number of moles of oxygen can be calculated using the molar volume.

Concentration of hydrogen peroxide = 0.833 mol dm^{-3}. [1]

d



correct representation of structure [1]

correct bond angles. [1]

3 a i $S_2O_8^{2-} + 2I^- \rightarrow I_2 + 2SO_4^{2-}$ [1]

Oxidation number of sulfur changes from +7 to +6, so sulfur is reduced. [1]

Oxidation number of iodine changes from −1 to 0, so iodine is oxidised. [1]

Therefore, this is a redox reaction. [1]

ii Both reactants are negatively charged and [1]

therefore repel each other, making it difficult for reaction to occur. [1]

iii either

use conductivity changes [1]

since the number of ions present decreases [1]

or

using colorimetry [1]

since iodine is produced that gives an orange/brown colour and therefore there is a change in absorption. [1]

b The iodine/iodide half reaction has a more negative electrode potential and therefore the reaction

$2e^- + I_2 \rightleftharpoons 2I^-$ can proceed to the left [1]

and the electrons can be accepted by the $S_2O_8^{2-}$ ions. [1]

c Fe^{2+} ions can react with $S_2O_8^{2-}$ ions: $2Fe^{2+} + 2S_2O_8^{2-} \rightarrow 2Fe^{3+} + 2SO_4^{2-}$. [1]

This reaction is quicker because the ions are oppositely charged and therefore attract each other. [1]

This reaction can happen because the half-cell reaction: $e^- + Fe^{3+} \rightleftharpoons Fe^{2+}$ has a more negative electrode potential and can therefore proceed to the left forming SO_4^{2-} ions and the electrons produced can reduce the $S_2O_8^{2-}$ ions. [1]

The Fe^{3+} ions react with I^- ions to give I_2 because the $2e^- + I_2 \rightleftharpoons 2I^-$ half-cell reaction has a more negative electrode potential than the Fe^{2+}/Fe^{3+} system [1]

and can therefore proceed to the left, forming iodine. [1]

The Fe^{3+} ions are reduced to Fe^{2+}, which are therefore regenerated and are therefore catalytic. [1]

d Only the VO_2^+ ions can act as catalysts because the standard electrode potential of the half-cell reaction involving the catalyst [1]

has to be intermediate between the other two electrode potentials. [1]