Electrolysis

Question Paper 1

Level	Pre U
Subject	Chemistry
Exam Board	Cambridge International Examinations
Topic	Electrolysis- Equilibria
Booklet	Question Paper 1

Time Allowed: **48 minutes**

Score: **/40**

Percentage: **/100**

Grade Boundaries:

1. **(a)** The reaction shown represents the hydrogenation of a vegetable oil.

$$RCH{=}CHR'(l) + H_2(g) \rightarrow RCH_2CH_2R'(l)$$

This reaction can be catalysed by several different transition metals and gives an example of heterogeneous catalysis.

State the three stages involved in a typical reaction involving a heterogeneous catalyst.

1. ....

2. ....

3. .... [1]

(b) An example of homogeneous catalysis is the use of iron(II) ions or iron(III) ions to catalyse the reaction between iodide ions and peroxodisulfate ions, $S_2O_8^{2-}$. This reaction is given in equation 3.1.

equation 3.1 $2I^-(aq) + S_2O_8^{2-}(aq) \rightarrow I_2(aq) + 2SO_4^{2-}(aq)$

The relevant half-equations are given in Table 3.1.

Table 3.1

half-equation	$E^\ominus$ /V
$S_2O_8^{2-}(aq) + 2e^- \rightleftharpoons 2SO_4^{2-}(aq)$	+2.01
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77
$I_2(aq) + 2e^- \rightleftharpoons 2I^-(aq)$	+0.54

(i) What is meant by the term *homogeneous catalysis*?

....

.... [1]

(ii) Use the data in Table 3.1 to calculate the standard cell potential, $E^\ominus_{cell}$, of the reaction shown in equation 3.1.

.... V [1]

(iii) Use your answer from **(b)(ii)** to calculate the standard Gibbs energy change, $\Delta_r G^{\ominus}$, of the reaction shown in equation 3.1. Give the sign and units in your answer.

.... [2]

(iv) Explain how your answer to **(b)(iii)** confirms that the reaction shown in equation 3.1 represents the feasible direction of reaction.

....

.... [1]

(v) State and explain why, despite being feasible, the reaction shown in equation 3.1 is not seen to occur in the absence of a catalyst.

....

....

.... [2]

(vi) By constructing suitable equations from the data in Table 3.1, explain why the reaction between iodide and peroxodisulfate can be catalysed by either iron(II) or iron(III) ions.

....

....

....

....

....

.... [3]

(c) Fig. 3.1 represents part of the structure of chymotrypsin, an enzyme produced by the pancreas that is responsible for catalysing the hydrolysis of certain proteins in the small intestine during the digestive process.

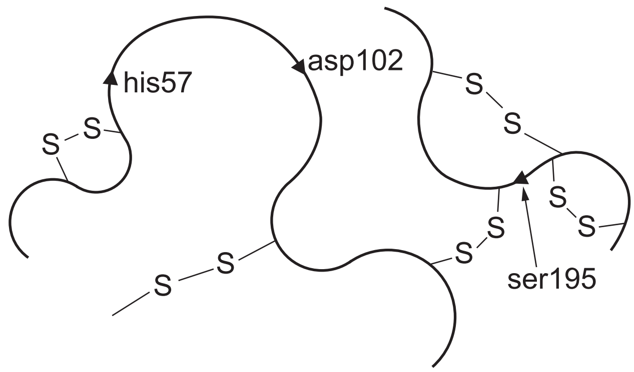

Fig. 3.1

The three main amino acids involved in the catalytic activity of the enzyme are labelled in Fig. 3.1 as his57, asp102 and ser195.

(i) What is the name of the region of the enzyme molecule that contains the three labelled amino acids and interacts with the protein being hydrolysed?

.... [1]

The first stage of the mechanism of action of chymotrypsin is illustrated in Fig. 3.2.

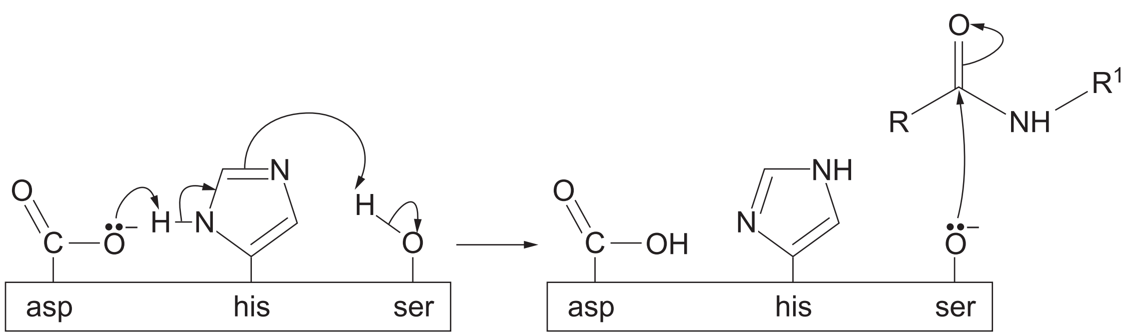

Fig. 3.2

(ii) Explain what is represented by a curly arrow as used in the mechanism shown in Fig. 3.2.

.... [1]

(iii) With reference to Fig. 3.2, explain why the action of this enzyme would be inhibited if the pH was too low.

....

....

.... [2]

(iv) Chymotrypsin is denatured by sodium hydroxide, with the mechanism dependent on the pH.

- At pH12 the reaction is first order with respect to both the chymotrypsin and the hydroxide.
- In the presence of excess alkali the denaturation of the enzyme was monitored.
- The plot of the time course of the reaction is shown in Fig. 3.3.

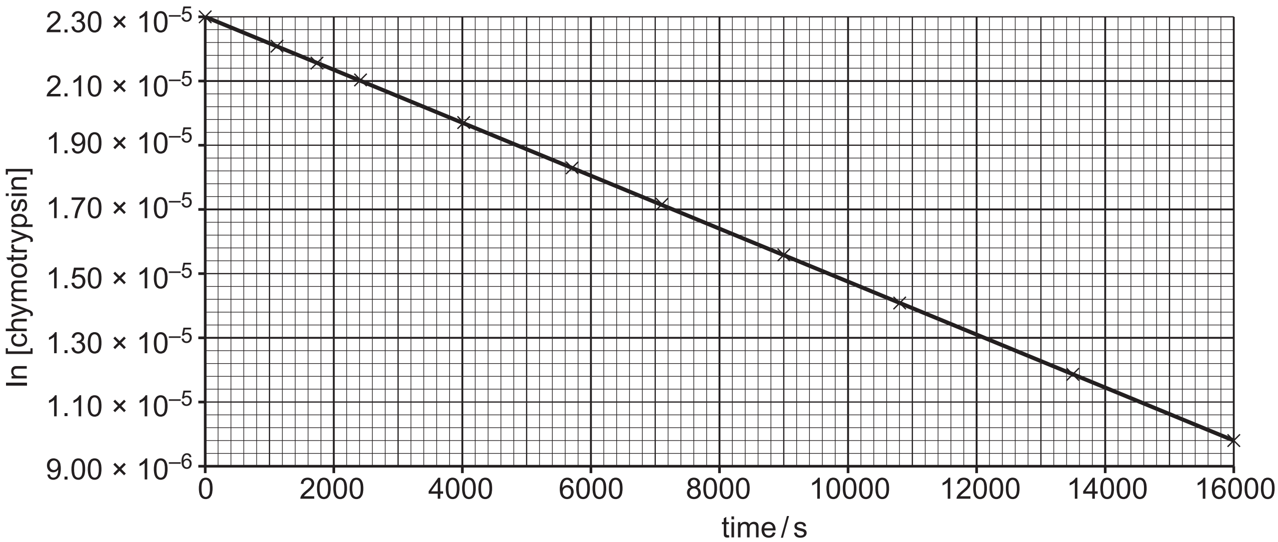

Fig. 3.3

The first order rate equation, equation 8 in the Data Booklet, can be rewritten as in equation 3.2.

equation 3.2 $\ln C_t = -kt + \ln C_0$

Given that equation 3.2 is in the form $y = mx + c$, explain how the graph in Fig. 3.3 confirms that the denaturation is first order with respect to chymotrypsin and how the conditions chosen give rise to first order kinetics overall.

....

....

....

.... [2]

(v) Use the graph in Fig. 3.3 to calculate the value of the first order rate constant for this denaturation.

k = ... [2]

[Total: 19]

2. Fig. 3.1 is a diagram of a hydrogen/oxygen fuel cell.

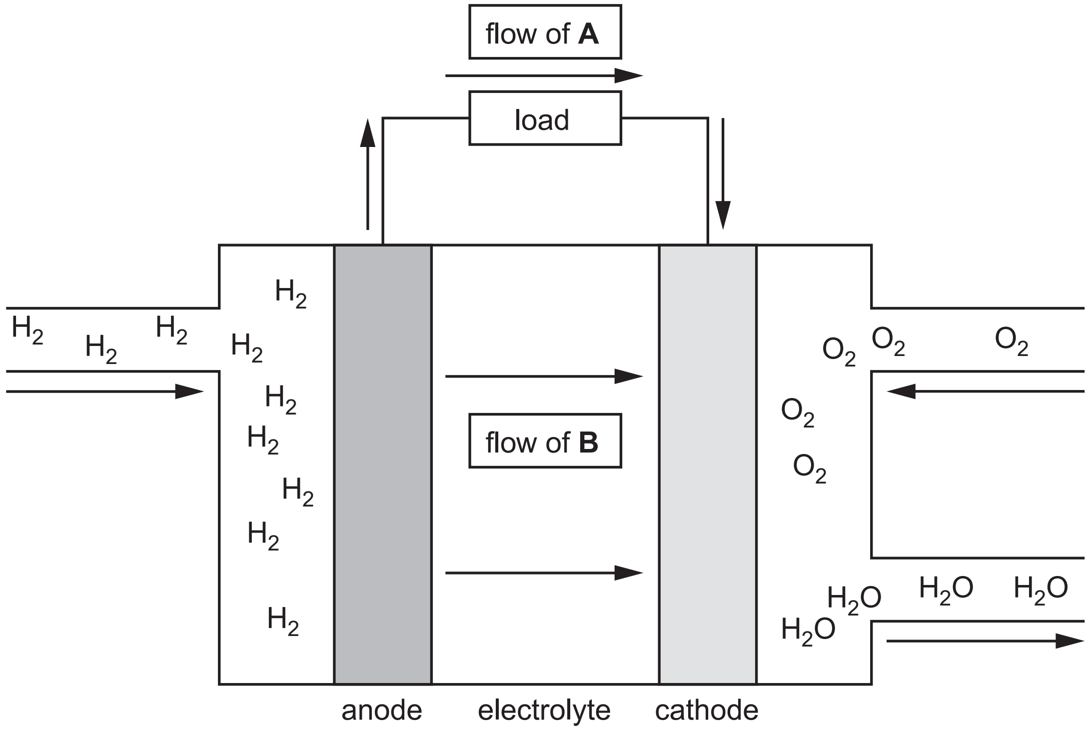

Fig. 3.1

(a) Identify the particles represented by:

A .... **B** .... [2]

(b) The cathode in this fuel cell is coated with a catalyst. Suggest a suitable material for this catalyst.

.... [1]

(c) Write the equation for the reaction occurring at each electrode.

cathode reaction ....

anode reaction .... [2]

(d) **(i)** One of the advantages of fuel cells over the use of fossil fuels is that the only by-product is water.
Suggest two **other** advantages of fuel cells over the use of fossil fuels in motor vehicles.

....

....

....

.... [2]

(ii) Apart from cost, suggest two disadvantages of using fuel cells rather than fossil fuels in motor vehicles.

....

....

....

.... [2]

(e) The zinc/silver oxide cell is used for button cells in watch batteries and is based on the following half-cells:

$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$ $\quad E^\ominus = -0.76\,V$

$Ag_2O(s) + H_2O(l) + 2e^- \rightleftharpoons 2Ag(s) + 2OH^-(aq)$ $\quad E^\ominus = +0.34\,V$

(i) Complete the left-hand side of the notation that describes this cell diagram. [1]

.... $||[Ag_2O(s) + H_2O(l)],[2Ag(s) + 2OH^-(aq)]|Ag(s)$

(ii) State which species is oxidised and which is reduced in this cell during use.

species being oxidised ....

species being reduced .... [2]

(iii) Write an overall equation for the reaction taking place in the cell during use.

.... [1]

(iv) Calculate the standard cell potential for the zinc/silver oxide cell.

$E^{\ominus}_{cell}$ = ... [1]

(v) Use your answer to part **(iv)** to calculate the standard Gibbs energy change ($\Delta_r G^{\ominus}$) for the reaction in this cell.

.... $kJ\,mol^{-1}$ [1]

(vi) Use your answer to part **(v)** to calculate the equilibrium constant (K_c) for the reaction in part **(iii)**.

K_c = ... [2]

[Total: 17]