

Name of the Student: _____

Max. Marks : 20 Marks

Time : 20 Minutes

Q1.

Hydrogen–oxygen fuel cells can operate in acidic or in alkaline conditions but commercial cells use porous platinum electrodes in contact with concentrated aqueous potassium hydroxide. The table below shows some standard electrode potentials measured in acidic and in alkaline conditions.

Half-equation	E° / V
$\text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}(\text{l})$	+1.23
$\text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + 4\text{e}^- \rightarrow 4\text{OH}^-(\text{aq})$	+0.40
$2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$	0.00
$2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow 2\text{OH}^-(\text{aq}) + \text{H}_2(\text{g})$	− 0.83

- (a) State why the electrode potential for the standard hydrogen electrode is equal to 0.00V.

(1)

- (b) Use data from the table to calculate the e.m.f. of a hydrogen–oxygen fuel cell operating in alkaline conditions.

(1)

- (c) Write the conventional representation for an alkaline hydrogen–oxygen fuel cell.

(2)

- (d) Use the appropriate half-equations to construct an overall equation for the reaction that occurs when an alkaline hydrogen–oxygen fuel cell operates. Show your working.

(2)

- (e) Give **one** reason, other than cost, why the platinum electrodes are made by coating a porous ceramic material with platinum rather than by using platinum rods.

(1)

- (f) Suggest why the e.m.f. of a hydrogen–oxygen fuel cell, operating in acidic conditions, is exactly the same as that of an alkaline fuel cell.

(1)

- (g) Other than its lack of pollution, state briefly the main advantage of a fuel cell over a re-chargeable cell such as the nickel–cadmium cell when used to provide power for an electric motor that propels a vehicle.

(1)

- (h) Hydrogen–oxygen fuel cells are sometimes regarded as a source of energy that is carbon neutral. Give **one** reason why this may **not** be true.

(1)

(Total 10 marks)

Q2.

Use the data in the table below, where appropriate, to answer the questions which follow.

Standard electrode potentials	$E^\ominus / \text{V}$
$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \longrightarrow \text{Fe}^{2+}(\text{aq})$	+0.77
$\text{Cl}_2(\text{g}) + 2\text{e}^- \longrightarrow 2\text{Cl}^-(\text{aq})$	+1.36
$2\text{BrO}_3^-(\text{aq}) + 12\text{H}^+(\text{aq}) + 10\text{e}^- \longrightarrow \text{Br}_2(\text{aq}) + 6\text{H}_2\text{O}(\text{l})$	+1.52
$\text{O}_3(\text{g}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \longrightarrow \text{O}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$	+2.08
$\text{F}_2\text{O}(\text{g}) + 2\text{H}^+(\text{aq}) + 4\text{e}^- \longrightarrow 2\text{F}^-(\text{aq}) + \text{H}_2\text{O}(\text{l})$	+2.15

Each of the above can be reversed under suitable conditions.

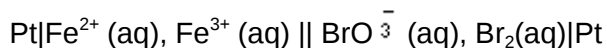
(a) (i) Identify the most powerful reducing agent in the table.

(ii) Identify the most powerful oxidising agent in the table.

(iii) Identify **all** the species in the table which can be oxidised in acidic solution by $\text{BrO}_3^- (\text{aq})$.

(4)

(b) The cell represented below was set up.



(i) Deduce the e.m.f. of this cell.

(ii) Write a half-equation for the reaction occurring at the negative electrode when current is taken from this cell.

(iii) Deduce what change in the concentration of $\text{Fe}^{3+}(\text{aq})$ would cause an increase in the e.m.f. of the cell. Explain your answer.

Change in concentration _____

Explanation _____

(6)

(Total 10 marks)