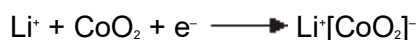


- Q1.** (a) Lithium ion cells are used to power cameras and mobile phones.
A simplified representation of a cell is shown below.



The reagents in the cell are absorbed onto powdered graphite that acts as a support medium. The support medium allows the ions to react in the absence of a solvent such as water.

The half-equation for the reaction at the positive electrode can be represented as follows.



- (i) Identify the element that undergoes a change in oxidation state at the positive electrode and deduce these oxidation states of the element.

Element

Oxidation state 1

Oxidation state 2

.....

(3)

- (ii) Write a half-equation for the reaction at the negative electrode during operation of the lithium ion cell.

.....

(1)

- (iii) Suggest two properties of platinum that make it suitable for use as an external electrical contact in the cell.

Property 1

Property 2

(2)

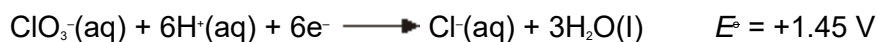
- (iv) Suggest **one** reason why water is **not** used as a solvent in this cell.

.....

.....

(1)

- (b) The half-equations for two electrodes used to make an electrochemical cell are shown below.



- (i) Write the conventional representation for the cell using platinum contacts.

.....

(2)

- (ii) Write an overall equation for the cell reaction and identify the oxidising and reducing agents.

Overall equation

.....

.....

Oxidising agent

Reducing agent

(3)

(Total 12 marks)

- Q2.** The electrons transferred in redox reactions can be used by electrochemical cells to provide energy.

Some electrode half-equations and their standard electrode potentials are shown in the table below.

Half-equation	E^\ominus/V
$\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 14\text{H}^+(\text{aq}) + 6\text{e}^- \rightarrow 2\text{Cr}^{3+}(\text{aq}) + 7\text{H}_2\text{O}(\text{l})$	+1.33
$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Fe}^{2+}(\text{aq})$	+0.77
$2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$	0.00
$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Fe}(\text{s})$	-0.44

$\text{Li}^+(\text{aq}) + \text{e}^- \rightarrow \text{Li}(\text{s})$	-3.04
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(a) Describe a standard hydrogen electrode.

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.....

.....

.....

(4)

(b) A conventional representation of a lithium cell is given below.
This cell has an e.m.f. of +2.91 V



Write a half-equation for the reaction that occurs at the positive electrode of this cell.

Calculate the standard electrode potential of this positive electrode.

.....

.....

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.....

.....

(2)

(c) Suggest what reactions occur, if any, when hydrogen gas is bubbled into a solution containing a mixture of iron(II) and iron(III) ions. Explain your answer.

.....

.....

.....

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)

Q4. Use the standard electrode potential data in the table below to answer the questions which follow.

			E^\ominus / V
$\text{Ce}^{4+}(\text{aq}) + \text{e}^-$	\rightleftharpoons	$\text{Ce}^{3+}(\text{aq})$	+1.70
$\text{MnO}^- (\text{aq}) + 8\text{H}^+(\text{aq}) + 5\text{e}^-$	\rightleftharpoons	$\text{Mn}^{2+}(\text{aq}) + 4\text{H}_2\text{O}(\text{l})$	+1.51
$\text{Cl}_2(\text{g}) + 2\text{e}^-$	\rightleftharpoons	$2\text{Cl}^-(\text{aq})$	+1.36
$\text{VO}_2^+(\text{aq}) + 2\text{H}^+(\text{aq}) + \text{e}^-$	\rightleftharpoons	$\text{VO}^{2+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$	+1.00
$\text{Fe}^{3+}(\text{aq}) + \text{e}^-$	\rightleftharpoons	$\text{Fe}^{2+}(\text{aq})$	+0.77



- (a) Name the standard reference electrode against which all other electrode potentials are measured.

.....

(1)

- (b) When the standard electrode potential for $\text{Fe}^{3+}(\text{aq}) / \text{Fe}^{2+}(\text{aq})$ is measured, a platinum electrode is required.

- (i) What is the function of the platinum electrode?

.....

- (ii) What are the standard conditions which apply to $\text{Fe}^{3+}(\text{aq})/\text{Fe}^{2+}(\text{aq})$ when measuring this potential?

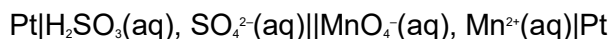
.....

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(3)

- (c) The cell represented below was set up under standard conditions.



Calculate the e.m.f. of this cell and write an equation for the spontaneous cell reaction.

Cell e.m.f.

Equation

.....

(3)

- (d) (i) Which one of the species given in the table is the strongest oxidising agent?

.....

- (ii) Which of the species in the table could convert $\text{Fe}^{2+}(\text{aq})$ into $\text{Fe}^{3+}(\text{aq})$ but could not convert $\text{Mn}^{2+}(\text{aq})$ into $\text{MnO}_4^{-}(\text{aq})$?

.....

(3)

- (e) Use data from the table of standard electrode potentials to deduce the cell which would have a standard e.m.f. of 0.93 V. Represent this cell using the convention shown in part (c).

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(2)

(Total 12 marks)