5 The table shows some electrode half-equations and the associated standard electrode potentials.

Equation number	Electrode half-equation	$E^{\ominus}$/V
1	$Cd(OH)_2(s) + 2e^- \rightarrow Cd(s) + 2OH^-(aq)$	–0.88
2	$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	–0.76
3	$NiO(OH)(s) + H_2O(l) + e^- \rightarrow Ni(OH)_2(s) + OH^-(aq)$	+0.52
4	$MnO_2(s) + H_2O(l) + e^- \rightarrow MnO(OH)(s) + OH^-(aq)$	+0.74
5	$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$	+1.23

5 (a) In terms of electrons, state the meaning of the term *oxidising agent*.

.....

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(1 mark)

5 (b) Deduce the identity of the weakest oxidising agent in the table.
Explain how $E^{\ominus}$ values can be used to make this deduction.

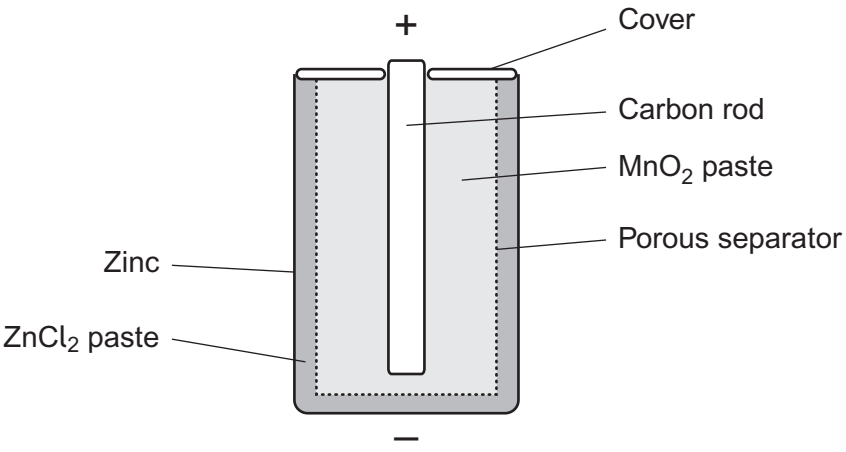
Weakest oxidising agent .....

Explanation .....

.....

(2 marks)

5 (c) The diagram shows a non-rechargeable cell that can be used to power electronic devices. The relevant half-equations for this cell are equations **2** and **4** in the table above.



5 (c) (i) Calculate the e.m.f. of this cell.

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(1 mark)

5 (c) (ii) Write an equation for the overall reaction that occurs when the cell discharges.

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(1 mark)

5 (c) (iii) Deduce **one** essential property of the non-reactive porous separator labelled in the diagram.

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(1 mark)

5 (c) (iv) Suggest the function of the carbon rod in the cell.

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(1 mark)

5 (c) (v) The zinc electrode acts as a container for the cell and is protected from external damage. Suggest why a cell often leaks after being used for a long time.

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(1 mark)

Question 5 continues on the next page

5 (d) A rechargeable nickel–cadmium cell is an alternative to the cell shown in part **(c)**. The relevant half-equations for this cell are equations **1** and **3** in the table on page 10.

5 (d) (i) Deduce the oxidation state of the nickel in this cell after recharging is complete. Write an equation for the overall reaction that occurs when the cell is **recharged**.

Oxidation state .....

Equation .....

.....

.....

(3 marks)

5 (d) (ii) State **one** environmental advantage of this rechargeable cell compared with the non-rechargeable cell described in part **(c)**.

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(1 mark)

5 (e) An ethanol–oxygen fuel cell may be an alternative to a hydrogen–oxygen fuel cell. When the cell operates, all of the carbon atoms in the ethanol molecules are converted into carbon dioxide.

5 (e) (i) Deduce the equation for the overall reaction that occurs in the ethanol–oxygen fuel cell.

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(1 mark)

5 (e) (ii) Deduce a half-equation for the reaction at the ethanol electrode. In this half-equation, ethanol reacts with water to form carbon dioxide and hydrogen ions.

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(1 mark)

5 (e) (iii) The e.m.f. of an ethanol–oxygen fuel cell is 1.00 V. Use data from the table on page 10 to calculate a value for the electrode potential of the ethanol electrode.

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(1 mark)

5 (e) (iv) Suggest why ethanol can be considered to be a carbon-neutral fuel.

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(2 marks)

17

Turn over for the next question