**4** **(a)** Define standard cell potential, $E^{\ominus}_{cell}$. Include a description of standard conditions.

.....

.....

..... [2]

**(b)** The Daniell cell is an electrochemical cell consisting of a $Cu^{2+}(aq)/Cu(s)$ electrode and a $Zn^{2+}(aq)/Zn(s)$ electrode.

**(i)** Draw a labelled diagram of this electrochemical cell.

Include all necessary substances and relevant pieces of apparatus needed to measure the $E^{\ominus}_{cell}$.

It is **not** necessary to state the conditions used.

[3]

**(ii)** State the charge carriers that transfer current through the solutions and through the wire.

the solutions ..... the wire ..... [1]

**(iii)** The standard electrode potential, $E^{\ominus}$, for the $Zn^{2+}(aq)/Zn(s)$ electrode is –0.76 V.

Water is added to a standard $Zn^{2+}(aq)/Zn(s)$ electrode.

The new concentration of $Zn^{2+}(aq)$ is 0.25 mol dm$^{-3}$.

Use the Nernst equation to calculate the electrode potential, $E$, for this new $Zn^{2+}(aq)/Zn(s)$ electrode.

$E$ ($Zn^{2+}(aq)/Zn(s)$) = ..... V [2]

**(c)** An electrochemical cell consists of a $ZnO/Zn$ electrode and a $MnO_2/Mn_2O_3$ electrode in an alkaline electrolyte.

The standard cell potential, $E^{\ominus}_{cell}$, for this cell is +1.47 V.

The half-equation at each electrode when this cell is discharging is shown.

$$Zn + 2OH^- \rightarrow ZnO + H_2O + 2e^-$$

$$2MnO_2 + H_2O + 2e^- \rightarrow Mn_2O_3 + 2OH^-$$

**(i)** Use this information to determine the change in oxidation state of manganese when this cell is discharging.

from ..... to ..... [1]

**(ii)** Write the equation for the overall reaction that occurs when this cell is discharging.

..... [1]

**(iii)** The $E^{\ominus}$ for the $ZnO/Zn$ electrode is –1.28 V.

Calculate the standard electrode potential, $E^{\ominus}$, for the $MnO_2/Mn_2O_3$ electrode.

$E^{\ominus}$ ($MnO_2/Mn_2O_3$) = ..... V [1]

[Total: 11]