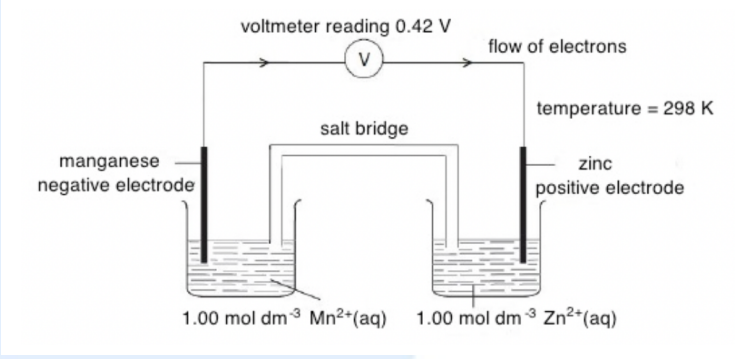
HL Paper 3 Section A Experimental work (9) with worked answers

Manganese is above zinc in the activity series. The total electromotive force (EMF) produced by connecting a $Zn(s)/Zn^{2+}(aq)$ half-cell to a $Mn(s)/Mn^{2+}(aq)$ half-cell operating under standard conditions is 0.42 V.

(a) Draw a clearly labelled diagram showing the apparatus and chemicals you could use in a school laboratory to confirm this information Your diagram should also show the direction of flow of electrons in the external circuit. (Upload your answer as an image or as a pdf file). ***[3]***



[3]

(b) You are provided with a piece of cobalt and a molar aqueous solution of cobalt nitrate, $Co(NO_3)_2$. Describe how you could determine practically without using a voltmeter whether the standard electrode potential for the $Co(s)/Co^{2+}(aq)$ half-cell is more negative or more positive than either or both of the two half-cells used in **(a)**. ***[2]***

Place a piece of cobalt in solutions of zinc ions and manganese ions and see if any deposit of zinc or manganese metal is formed. If there is, the value of $E^{\ominus}$ for $Co(s)/Co^{2+}(aq)$ is more negative. If not, place pieces of zinc and manganese in solutions of cobalt(II) ions and see if any cobalt metal is deposited, if there is, the value of $E^{\ominus}$ $Co(s)/Co^{2+}(aq)$ is less negative (more positive). ***[2]***
Note that although it may be difficult to distinguish between the different metals by colour etc. it should be obvious if there is no reaction or, if it is left overnight, whether crystals of a different metal have formed.

(c) When a voltmeter is used the potential difference between a $Co(s)/Co^{2+}(aq)$ half-cell and a $Mn(s)/Mn^{2+}(aq)$ half-cell is found to be 0.90 V and the potential difference between a $Co(s)/Co^{2+}(aq)$ half-cell and a $Zn(s)/Zn^{2+}(aq)$ half-cell is found to be 0.48 V.
Determine the standard electrode potential of the $Co(s)/Co^{2+}(aq)$ half-cell using information given in Section 24 of the data booklet. ***[1]***

From the readings the $Co(s)/Co^{2+}(aq)$ half-cell must have an $E^{\ominus}$ value more positive (less negative) than both the $Zn(s)/Zn^{2+}(aq)$ and $Mn(s)/Mn^{2+}(aq)$ half-cells. Since $E^{\ominus}$ for $Zn(s)/Zn^{2+}(aq)$ is – 0.76 V (or $E^{\ominus}$ for $Mn(s)/Mn^{2+}(aq)$ is – 1.18 V), $E^{\ominus}$ for the $Co(s)/Co^{2}+(aq)$ half-cell must be – 0. 28 V. ***[1]***

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