AQA – Electrode potentials and electrochemical cells – A2 Chemistry P3

1. June/ 2020/Paper_3/No.6

0 6 Standard electrode potentials are measured by comparison with the standard hydrogen electrode.

0 6 . 1 State the substances and conditions needed in a standard hydrogen electrode.

[3 marks]

It is difficult to ensure consistency with the setup of a standard hydrogen electrode. A $Cu^{2+}(aq)/Cu(s)$ electrode ($E^{\ominus}$ = +0.34 V) can be used as a secondary standard.

A student does an experiment to measure the standard electrode potential for the $TiO^{2+}(aq)/Ti(s)$ electrode using the $Cu^{2+}(aq)/Cu(s)$ electrode as a secondary standard.

A suitable solution containing the acidified $TiO^{2+}(aq)$ ion is formed when titanium(IV) oxysulfate ($TiOSO_4$) is dissolved in 0.50 mol dm^{-3} sulfuric acid to make 50 cm^3 of solution.

0 6 . 2 Describe an experiment the student does to show that the standard electrode potential for the $TiO^{2+}(aq)/Ti(s)$ electrode is –0.88 V

The student is provided with:

- the $Cu^{2+}(aq)/Cu(s)$ electrode set up ready to use
- solid titanium(IV) oxysulfate (M_r = 159.9)
- 0.50 mol dm^{-3} sulfuric acid
- a strip of titanium
- laboratory apparatus and chemicals.

Your answer should include details of:

- how to prepare the solution of acidified $TiO^{2+}(aq)$
- how to connect the electrodes
- measurements taken
- how the measurements should be used to calculate the standard electrode potential for the $TiO^{2+}(aq)/Ti(s)$ electrode.

[6 marks]

0 6 . 3 Give the half-equation for the electrode reaction in the $TiO^{2+}(aq)/Ti(s)$ electrode in acidic conditions.

[1 mark]

0 6 . 4 **Table 2** shows some electrode potential data.

Table 2

Electrode reaction	$E^{\ominus}$ / V
$2H^+(aq) + 2e^- \rightarrow H_2(g)$	0.00
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.34
$NO_3^-(aq) + 4H^+(aq) + 3e^- \rightarrow NO(g) + 2H_2O(l)$	+0.96

Use the data in **Table 2** to explain why copper does **not** react with most acids but does react with nitric acid.

Give an equation for the reaction between copper and nitric acid.

[3 marks]

Explanation

Equation

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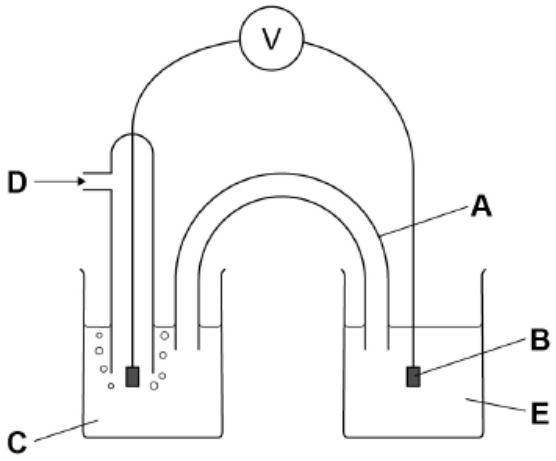
0 3 **Figure 1** represents the cell used to measure the standard electrode potential for the Fe^{3+}/Fe^{2+} electrode.

Figure 1



0 3 . 1 Name the piece of apparatus labelled **A**.

[1 mark]

_____

0 3 . 2 State the purpose of **A**.

[1 mark]

_____

_____

0 3 . 3 Name the substance used as electrode **B** in **Figure 1**.

[1 mark]

_____

0 3 . 4 Complete **Table 1** to identify **C**, **D** and **E** from **Figure 1**.
Include the essential conditions for each.

[4 marks]

Table 1

	Identity	Conditions
C		
D		
E		

0 3 . 5 The standard electrode potential, $E^{\ominus}$, for the Fe^{3+}/Fe^{2+} electrode is +0.77 V

Give the ionic equation for the overall reaction in the cell in **Figure 1**.

State the change that needs to be made to the apparatus in **Figure 1** to allow the cell reaction to go to completion.

[2 marks]

Ionic equation _____

Change _____

_____

0 3 . 6 A student sets up a cell as shown in the cell representation.

$$Zn(s)|Zn^{2+}(aq)||Cu^{2+}(aq)|Cu(s)$$

The student measures the cell EMF, E_{cell}, with several different concentrations of Cu^{2+} ions and Zn^{2+} ions.

The results are shown in **Table 2**.

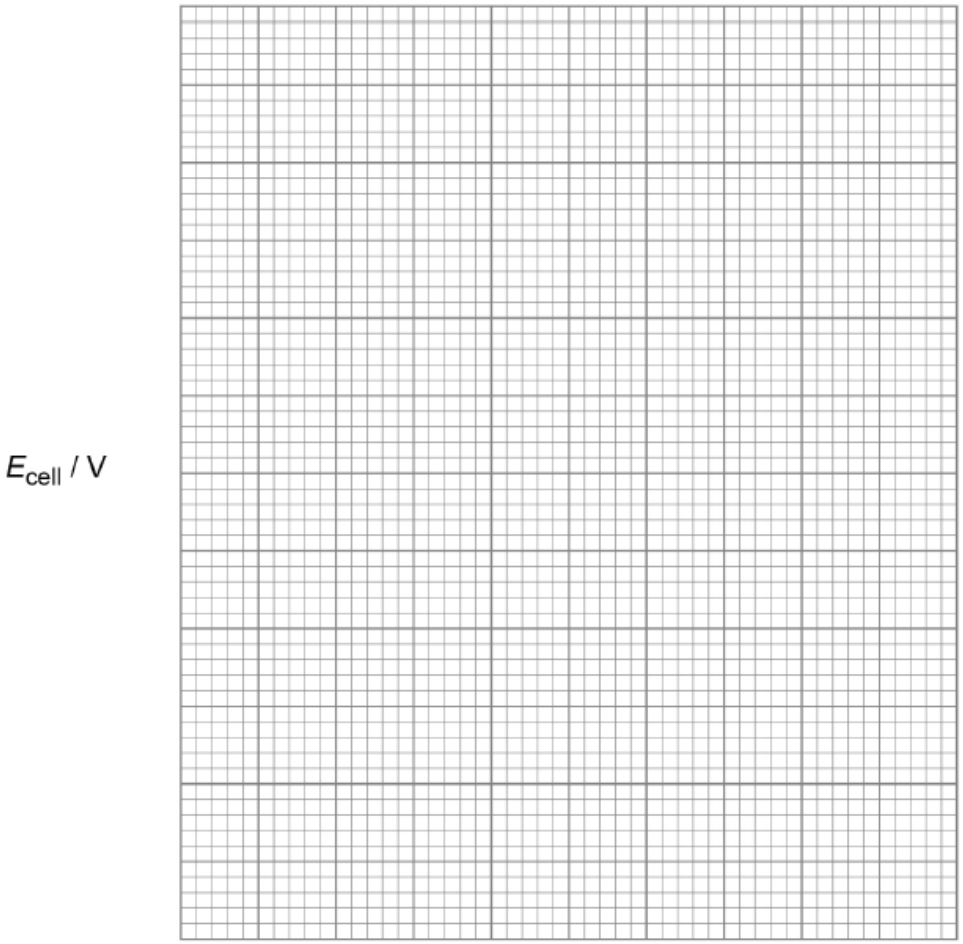
Table 2

Experiment	$[Zn^{2+}]$ / mol dm^{-3}	$[Cu^{2+}]$ / mol dm^{-3}	$\ln\left(\frac{[Zn^{2+}]}{[Cu^{2+}]}\right)$	E_{cell} / V
1	0.010	1.0	–4.61	1.16
2	0.10	1.0	–2.30	1.13
3	1.0	1.0	0.00	1.10
4	1.0	0.10		1.07
5	1.0	0.010	4.61	1.04

Complete **Table 2** to show the value missing from experiment **4**.

Plot a graph of E_{cell} against ln ($[Zn^{2+}]/[Cu^{2+}]$) on the grid.

[3 marks]



0 3 . 7 This equation shows how E_{cell} varies with concentration for this reaction.

$$E_{cell} = (-4.3 \times 10^{-5} \times T) \ln\left(\frac{[Zn^{2+}]}{[Cu^{2+}]}\right) + E^{\ominus}_{cell}$$

This equation is in the form of the equation for a straight line, y = mx + c

Calculate the gradient of your plotted line on the graph in question **03.6**.
You must show your working.

Use your gradient to calculate the temperature, T, at which the measurements of E_{cell} were taken.
(If you were unable to calculate a gradient you should use the value –0.016 V
This is **not** the correct value.)

[3 marks]

Gradient _____ V

T _____ K

0 3 . 8 In experiment **2** in **Table 2** the electrode potential of the Cu^{2+}/Cu electrode is +0.33 V

Use data from **Table 2** in question **03.6** to calculate the electrode potential for the Zn^{2+}/Zn electrode in experiment **2**.

Give one reason why your calculated value is different from the standard electrode potential for Zn^{2+}/Zn electrode.

[2 marks]

Electrode potential _____ V

Reason _____

_____

_____

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The $E^{\ominus}$ values for two electrodes are shown.

$$Fe^{2+}(aq) + 2e^{-} \rightarrow Fe(s) \quad E^{\ominus} = -0.44\ V$$

$$Cu^{2+}(aq) + 2e^{-} \rightarrow Cu(s) \quad E^{\ominus} = +0.34\ V$$

What is the EMF of the cell $Fe(s)|Fe^{2+}(aq)||Cu^{2+}(aq)|Cu(s)$?

[1 mark]

A +0.78 V ⬭

B +0.10 V ⬭

C –0.10 V ⬭

D –0.78 V ⬭