BETH "KEY"

Redox Review Questions

1a. *[1 mark]*

Define *oxidation* in terms of oxidation number.

oxidation number increases.

1b. *[2 marks]*

Deduce the balanced chemical equation for the redox reaction of copper, Cu(s), with nitrate ions, $NO^{3-}(aq)$, **in acid**, to produce copper(II) ions, $Cu^{2+}(aq)$, and nitrogen(IV) oxide, $NO_2(g)$.

$Cu \rightarrow Cu^{2+} + 2e^-$

~~$2(2H^+ + e^- + NO_3^- \rightarrow NO_2 + H_2O)$~~

$4H^+ + 2e^- + 2NO_3^- \rightarrow 2NO_2 + 2H_2O$

$\overset{+1}{4H^+_{(aq)}} + \overset{0}{Cu_{(s)}} + \overset{+5\,-2}{2NO_{3(aq)}^-} \rightarrow \overset{+2}{Cu^{2+}_{(aq)}} + \overset{+4\,-2}{2NO_{2(g)}} + \overset{+1\,-2}{2H_2O_{(l)}}$

1c. *[1 mark]*

Deduce the oxidizing and reducing agents in this reaction.

Oxidizing agent:

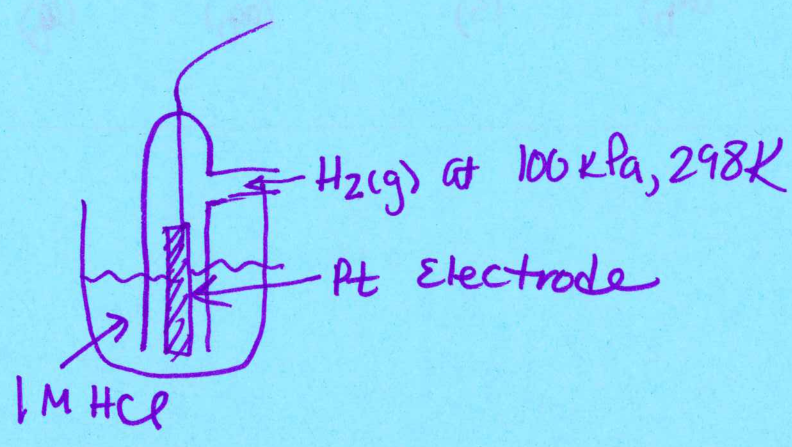
Reducing agent:

Oxidizing Agent = NO_3^-
Reducing Agent = Cu

1d. *[3 marks]*

A voltaic cell was set up, using the standard hydrogen electrode as a reference electrode and a standard $Cu^{2+}(aq)/Cu(s)$ electrode.

Describe the standard hydrogen electrode including a fully labelled diagram.



1e. *[1 mark]*

Define the term *standard electrode potential*, $E^{\ominus}$.

The potential of a half-reaction measued when connected to a SHE under standard conditions.

1f. *[2 marks]*

Deduce a balanced chemical equation, including state symbols, for the overall reaction which will occur spontaneously when the two half-cells are connected. (as described in 1d

$Cu^{2+}(aq) + H_2(g) \rightarrow Cu(s) + 2H^+(aq)$

1g. *[1 mark]*

Another voltaic cell was set up, using a $Sn^{2+}(aq)/Sn(s)$ half-cell and a $Cu^{2+}(aq)/Cu(s)$ half-cell under standard conditions.

Using Table 14 of the Data Booklet, calculate the cell potential, $E^{\ominus}_{cell}$, in V, when the two half-cells are connected.

$Sn_{(s)} \rightarrow Sn^{2+}_{(aq)} + 2e^-$ $+0.14V$

$Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$ $+0.34V$

$+0.48V$

Water in a beaker at a pressure of 1.01×10^5 Pa and a temperature of 298 K will not spontaneously decompose. However, decomposition of water can be induced by means of electrolysis.

1h. *[1 mark]*

State why dilute sulfuric acid needs to be added in order for the current to flow in the electrolytic cell.

It provides ions to carry current. H_2O is a poor/nonconductor.

1i. *[1 mark]*

State why copper electrodes cannot be used in the electrolysis of water. Suggest instead suitable **metallic** electrodes for this electrolysis process.

Cu will react. ~~Graphite (carbon)~~ ~~or~~ Pt should be used.

1j. *[2 marks]*

Deduce the half-equations for the reactions occurring at the positive electrode (anode) and the negative electrode (cathode).

Positive electrode (anode):

Negative electrode (cathode):

Positive electrode (anode):

$2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

Negative electrode (cathode):

$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

1l. *[1 mark]*

Deduce the overall cell reaction, including state symbols.

$2H_2O(l) \rightarrow 2H_{2(g)} + O_2(g)$

~~$2(2H_2O + 2e^- \rightarrow H_{2(g)} + 2OH^-(aq))$~~

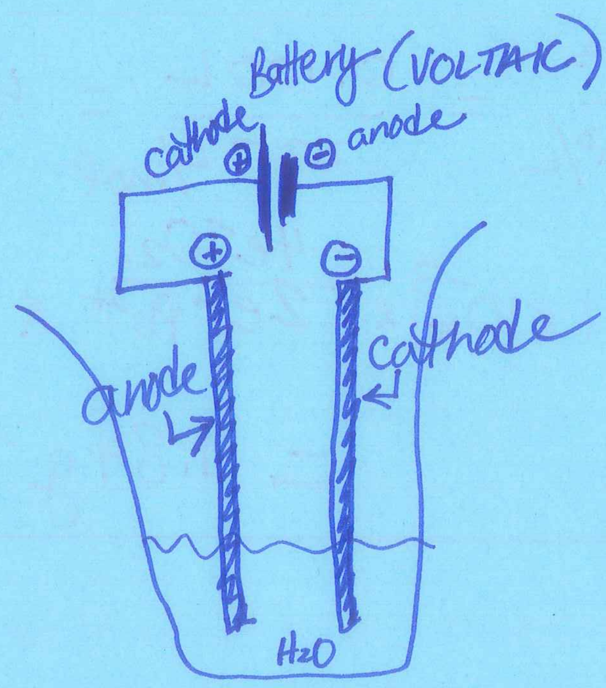
$2H_2O \rightarrow O_2 + 4H^+ + 4e^-$

$4H_2O + 4e^- \rightarrow 2H_2 + 4OH^-$ $4H_2O$

1m. *[2 marks]*

—described above 1h

Draw a fully labelled diagram of the electrolytic cell, showing the positive electrode (anode) and the negative electrode (cathode).



1n. *[1 mark]*

Comment on what is observed at both electrodes.

H_2O is reduced at the cathode,
H_2O is oxidized at the anode,
Bubbles of O_2 and H_2 will form,

1o. *[2 marks]*

Two electrolytic cells are connected in series (the same current passes through each cell). One cell for the electrolysis of water produces 100 cm^3 of oxygen, measured at 273 K and 1.01×10^5 Pa. The second cell contains molten lead(II) bromide, $PbBr_2$. Determine the mass, in g, of lead produced.

STP

$\frac{100\ cm^3}{1000\ cm^3/L} = \frac{0.100\ L}{22.7\ L/mol} = 4.41 \times 10^{-3}\ mol\ O_2$

$4.41 \times 10^{-3}\ mol \times \frac{4e^-\ O_2}{2e^-\ Pb^{2+}} \times 207.19\ g/mol\ Pb$

$= 1.84\ g\ Pb$

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