Friday Worksheet **Name: ……………….**

Fuel cells worksheet 1

1) A hydrogen-oxygen fuel cell can operate with an alkaline electrolyte such as potassium hydroxide. The overall reaction is given below

$2H_2(g) + O_2(g) \rightleftharpoons 2H_2O(l)$

a) Write the half-equation for the reaction that occurs at the cathode.

The reduction reaction takes place at the cathode.

Step 1 since oxygen goes from an oxidation state of 0 to -2 it is reduced. Write the reduction reaction
$O_2(g) \rightarrow H_2O(l)$
Balance for oxygens by adding H_2O on the right
$O_2(g) \rightarrow 2H_2O(l)$
Balance for hydrogens by adding H^+ on the left
$4H^+(aq) + O_2(g) \rightarrow 2H_2O(l)$
Balance for charge by adding electrons to the most positive side
$4e + 4H^+(aq) + O_2(g) \rightarrow 2H_2O(l)$
Now remove H^+ ions by adding OH^- ions to both sides, since it is an alkaline electrolyte.
$4e + 4H^+(aq) + 4OH^-(aq) + O_2(g) \rightarrow 2H_2O(l) + 4OH^-(aq)$
$\Rightarrow 4e + 4H_2O(l) + O_2(g) \rightarrow 2H_2O(l) + 4OH^-(aq)$
$\Rightarrow 4e + 2H_2O(l) + O_2(g) \rightarrow 4OH^-(aq)$

b) Write the half-equation for the reaction that occurs at the anode.

Step 1 since hydrogen goes from an oxidation state of 0 to +1 it is oxidised. Write the oxidation reaction
$H_2(g) \rightarrow H_2O(l)$
Balance for oxygens by adding H_2O on the left
$H_2(g) + H_2O(l) \rightarrow H_2O(l)$
Balance for hydrogens by adding H^+ on the right
$H_2(g) + H_2O(l) \rightarrow H_2O(l) + 2H^+(aq)$
Balance for charge by adding electrons to the most positive side
$H_2(g) + H_2O(l) \rightarrow 2H_2O(l) + 2H^+(aq) + 2e$
Now remove H^+ ions by adding OH^- ions to both sides, since it is an alkaline electrolyte.
$H_2(g) + H_2O(l) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2H^+(aq) + 2OH^-(aq) + 2e$
$\Rightarrow H_2(g) + H_2O(l) + 2OH^-(aq) \rightarrow 3H_2O(l) + 2e$
$\Rightarrow H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e$

c) This hydrogen-oxygen fuel cell uses 1.45×10^{-5} mol of hydrogen gas per second of operation. What is the current produced by this cell?

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

According to the equation above, for every mol of H_2 gas used 2 mol of electron is produced.

=> $n_e = 2.90 \times 10^{-5}$

Find the charge produced by this mol of electrons using Faraday's constant

=> $Q = 2.90 \times 10^{-5} \times 96{,}500 = 2.80$ Coulomb

Find the current

I = Q X t where Q is charge in Coulomb and t is time in seconds and I is current in amps

Current = 2.80 X 1 = 2.80 Amps

d) What is the maximum voltage predicted for one alkaline hydrogen/oxygen fuel cell under standard conditions?

0.40 - - 0.83 = 1.23 V

$O_2(g) + 2H_2O(l) + 4e^- \rightleftharpoons 4OH^-(aq)$	+0.40
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	+0.34
$Sn^{4+}(aq) + 2e^- \rightleftharpoons Sn^{2+}(aq)$	+0.15
$S(s) + 2H^+(aq) + 2e^- \rightleftharpoons H_2S(g)$	+0.14
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	0.00
$Pb^{2+}(aq) + 2e^- \rightleftharpoons Pb(s)$	−0.13
$Sn^{2+}(aq) + 2e^- \rightleftharpoons Sn(s)$	−0.14
$Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$	−0.23
$Co^{2+}(aq) + 2e^- \rightleftharpoons Co(s)$	−0.28
$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	−0.44
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	−0.76
$2H_2O(l) + 2e^- \rightleftharpoons H_2(g) + 2OH^-(aq)$	−0.83

2) Which of the following are advantages of modern fuel cells over conventional methods of electricity generation.

i. They generate very little noise.

ii. They are a cheap source of electricity.

iii. They enable electricity to be generated on site.

iv. They have the potential to reduce emissions of carbon dioxide into the atmosphere

I,iii and iv. At the moment fuel cells are very expensive.