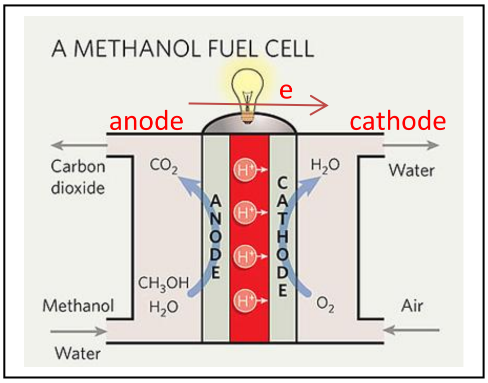
Friday Worksheet **Name: ……………….**

Fuel cells worksheet 2

1) Methanol is suitable for use in a micro fuel cell that is used to power laptop computers and similar small electrical items. The methanol is mixed with air and oxidised to carbon dioxide and water.
The overall reaction is given below

$2CH_3OH(l) + 3O_2(g) \Rightarrow 2CO_2(g) + 4H_2O(l)$



i. On the diagram on the right label the following
- the cathode
- the anode
- the direction of electron flow

ii. Write a balanced half-equation for the cathode reaction.
The cathode is where reduction occurs. It is where electrons are used. Since oxygen gas has an oxidation number of 0 on the right and -2 on the left it is reduced.

$4e + 4H^+(aq) + O_2 \Rightarrow 2H_2O$

iii. Write a balanced half-equation for the anode reaction.
The anode is where oxidation occurs and where electrons are produced.
$H_2O(l) + CH_3OH(l) \Rightarrow CO_2(g) + 6H^+(aq) + 6e$

iv. A finely divided platinum/ruthenium catalyst is used in this cell.

i. What is the purpose of this catalyst?
Increases the rate of a reaction by reducing the activation energy necessary for fruitful collisions.

ii. Give a reason why a catalyst is necessary for the fuel cell reaction.
Current must be supplied instantaneously and at maximum levels once connections are made. Students who stated that a catalyst increase the voltage supplied do not understand how a catalyst works. Just likje a catalyst does not change the ΔH of a reaction so does the catalyst not change the voltage generated by a reaction.

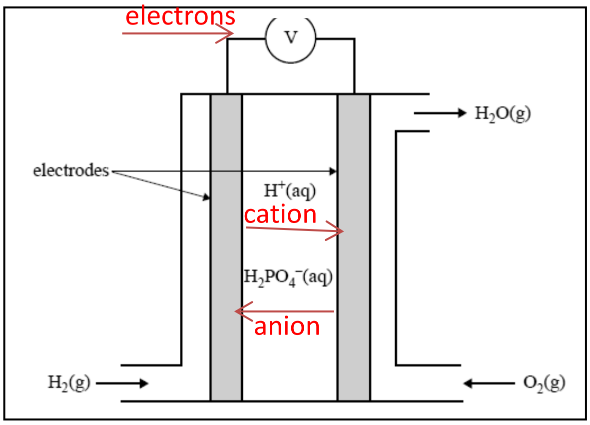
v. What mass of methanol is used to produce a charge of 4.50×10^3 Coulombs?
$H_2O(l) + CH_3OH(l) \Rightarrow CO_2(g) + 6H^+(aq) + 6e$
According to the equation above for every mol of methanol 6 mol of electrons are produced .
Step 1 find the mol of electrons
$\Rightarrow n_e = 4500/96500 =/96500=0.0466$
Step 2 find the mol of methanol
$\Rightarrow n_{methanol} = 0.0466/6 = 7.77 \times 10^{-3}$
Step 3 find the mass of methanol
$\Rightarrow$ mass $= n \times F_m = 7.77 \times 10^{-3} \times 32.0 = 0.249$ grams

vi. The cell provides a current of 1.89 Amps for a period of 35.8 seconds. What mass of carbon dioxide is produced?

Step 1 calculate the charge produced by the cell
Q = I X t = 1.89 X 35.8 = 67.7 Coulomb

Step 2 Calculate the mol of electrons
$n_e = 67.7 / 96500 = 7.01 \times 10^{-4}$

2) The phosphoric acid fuel has concentrated phosphoric acid as the electrolyte and hydrogen and oxygen gases as the reactants. A simplified view of the cell is shown on the right.
The overall reaction is $2H_2(g) + O_2(g) \Rightarrow 2H_2O(g)$



a) Write the equation for the half-cell reaction at the:
I. anode
Oxidation occurs at the anode. Electrons are produced .
$H_2(g) \Rightarrow H_2O(g)$
balance for oxygens by adding water to the left side
$H_2O(g) + H_2(g) \Rightarrow H_2O(g)$
balance for hydrogens by adding H^+ to the right side
$H_2O(g) + H_2(g) \Rightarrow H_2O(g) + 2H^+(aq)$
balance for charge by adding electrons to the most positive side
$H_2O(g) + H_2(g) \Rightarrow H_2O(g) + 2H^+(aq) + 2e$
Cancel the water molecules that appear on both sides
$H_2(g) \Rightarrow 2H^+(aq) + 2e$
ii. Cathode
Reduction occurs at the cathode. Electrons are used .
$O_2(g) \Rightarrow H_2O(g)$
balance for oxygens by adding water to the right side
$O_2(g) \Rightarrow 2H_2O(g)$
balance for hydrogens by adding H^+ to the left side
$4H^+(aq) + O_2(g) \Rightarrow 2H_2O(g)$
balance for charge by adding electrons to the most positive side
$4e + 4H^+(aq) + O_2(g) \Rightarrow 2H_2O(g)$

b) Indicate on the diagram the:
i. direction of electron flow,
ii. direction of cation movement,
iii. direction of anion movement.

c) Given that energy can be calculated using the formula E = VIt, where E is energy in Joules, V is volts, I is current in Amps and t is time in seconds, how much energy, in kJ, is delivered per mole of hydrogen in this fuel cell if it operates at a voltage of 0.750V?

Step 1 IX t = Q charge in Coulombs

Step 2 calculate the charge delivered by one mol of hydrogen
$H_2(g)$ => $2H^{+}(aq)$ + 2e
One mol of hydrogen produces 2 mol of electrons
The charge of 2 mol of electons is
Q = 2.00 X 96500 = 193000

Step 3 calculate the energy in Joules
E = 0.750 X 193000 = 145 kJ

d) Compare the energy delivered per mole of hydrogen in the fuel cell, as calculated in c) above and the heat of combustion of hydrogen, calculate the energy efficiency of this fuel cell.

molar enthalpy of combustion = -286 kJ

Cell energy output per mol of H_2 = 145 kJ
Efficiency % = (145/286) X 100 = 50.7%