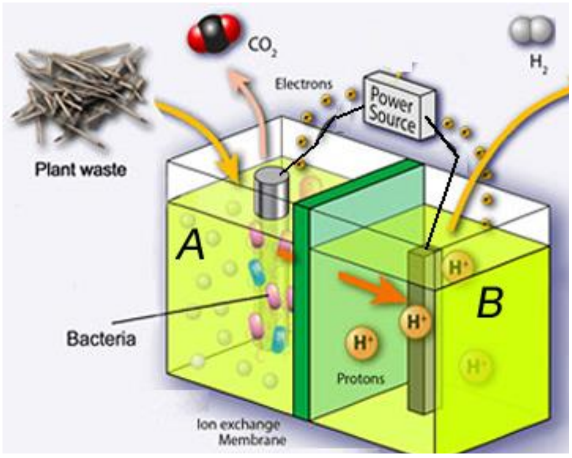
**Friday Worksheet** **Name: ……………….**

**Electrolysis worksheet 3**

1) Hydrogen gas can be used as an energy source. Researchers are investigating the production of hydrogen gas in a microbial electrolysis cell.
The cell is made up of an anode half-cell and a cathode half-cell. The half-cells are separated by a proton exchange membrane, as shown in the diagram .




A number of reactions take place in the cell, resulting in the production of hydrogen. Bacteria consume acetic acid, which is produced from fermenting plant matter and release protons, electrons and $CO_2$. Addition of an electric current enables the protons and electrons to join together to make hydrogen gas and the higher the current, the more hydrogen is produced. Oxygen gas must be excluded from both cells.

a) Which cell represents the anode? Explain

The anode half-cell is "A". Bacteria consume acetic acid, which is produced from fermenting plant matter and release protons, <u>electrons</u> and $CO_2$. Oxidation produces electrons and hence always occurs at the anode.

b) What is the polarity of the electrode in half-cell "A"?

This is the oxidation half-cell and hence the anode. In an electrolytic cell the anode is positive

c) What is the reaction taking place at the anode?

Since we are told that bacteria consume acetic acid and produce carbon dioxide we can write the equation below

$CH_3COOH(aq) \Rightarrow CO_2$

Balance for carbons

$CH_3COOH(aq) \Rightarrow 2CO_2$

Balance for oxygen by adding water to the left

$CH_3COOH(aq) + 2H_2O(l) \Rightarrow 2CO_2(g)$

Balance for hydrogen by adding $H^+$ to the right side

$CH_3COOH(aq) + 2\ H_2O(l) \Rightarrow 2CO_2(g) + 8H^+(aq)$

Balance for charge by adding electron to the most positive side

$CH_3COOH(aq) + 2\ H_2O(l) \Rightarrow 2CO_2(g) + 8H^+(aq) + 8e$

d) What is the reaction taking place at the cathode?

We are told in the question that $H^+$ ions combine with electrons to form $H_2$ gas. This is a reduction reaction and must occur at the cathode which is negative

$2H^+(aq) + 2e \Rightarrow H_2(g)$

e) Give the reaction occurring at the cathode if oxygen gas was present.

Cathode = site of reduction, strongest oxidant present will react.
$O_2(g) + 4H^+(aq) + 4e \Rightarrow 2H_2O(l)$

$$O_2(g) + 4H^+(aq) + 4e^- \rightleftharpoons 2H_2O(l)$$
$$Br_2(l) + 2e^- \rightleftharpoons 2Br^-(aq)$$
$$Ag^+(aq) + e^- \rightleftharpoons Ag(s)$$
$$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$$
$$O_2(g) + 2H^+(aq) + 2e^- \rightleftharpoons H_2O_2(aq)$$
$$I_2(s) + 2e^- \rightleftharpoons 2I^-(aq)$$
$$O_2(g) + 2H_2O(l) + 4e^- \rightleftharpoons 4OH^-(aq)$$
$$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$$

f) The cell runs for 25.0 minutes at a current of 6.73 A.
What volume, in litres, of hydrogen was produced at SLC?

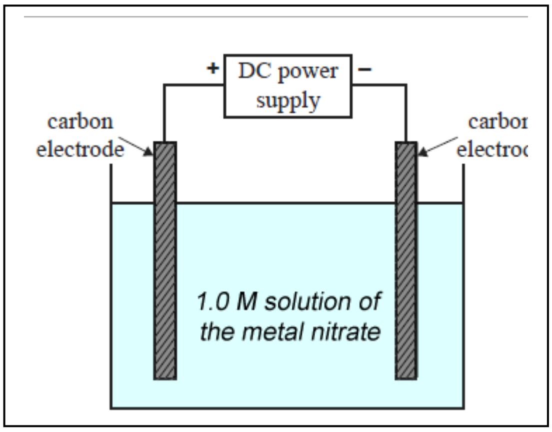
Step 1 Find the charge delivered in 25.0 minutes
=> Q = It => 6.73 X 25.0 X 60 = 10095

Step 2 find the mol of electrons
$n_e$ = 10095/96500 = 0.105

Step 3 find the mol of hydrogen gas
According the equation $2H^+(aq) + 2e \Rightarrow H_2(g)$ mol of hydrogen gas produced is half the mol of electrons used.
$n_{hydrogen}$ = 0.105/2

Step 4 find the volume at SLC
=> V = 24.5 X 0.105/2 = 1.28 L

2) A series of electrolysis experiments is conducted using the apparatus shown on the right.




An electric charge of 0.140 faraday was passed through separate solutions of 1.0 $Cr(NO_3)_3$, 1.0 M $Cu(NO_3)_2$ and 1.0 M $AgNO_3$. In each case the corresponding metal was deposited on one of the electrodes.

a) What is the polarity of the electrode on which each metal is deposited?
Depositing of metal is a reduction reaction that takes place at the cathode.
It is the negative electrode

b) Calculate the amount, in grams, of each metal deposited.
Step 1 calculate the mol of electrons delivered.
=> $n_e$ = 0.140
Step 2 write the reduction reactions of each metal.
$Cr^{3+}(aq) + 3e \Rightarrow Cr(s)$
$Cu^{2+}(aq) + 2e \Rightarrow Cu(s)$
$Ag^+(aq) + e \Rightarrow Ag(s)$
Step 3 find the mol of each metal and henc e it smass.
$n_{Cr}$ = 0.140/3 => $mass_{Cr}$ = (0.140/3) X 52.0 = 2.43
$n_{Cu}$ = 0.140/2 => $mass_{Cu}$ = (0.140/2) X 63.5 = 4.45
$n_{Ag}$ = 0.140 => $mass_{Cr}$ = (0.140) X 107.9 = 15.1