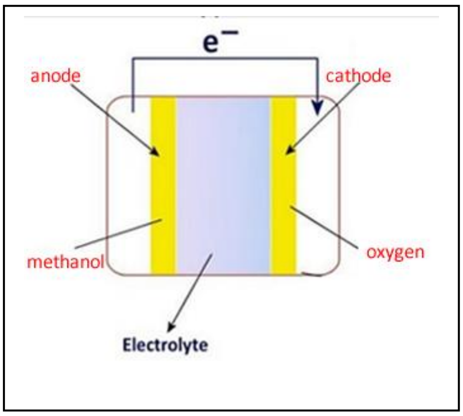
Redox reactions - revision
Lesson 7b

1) A fuel cell uses methanol in a combustion reaction that produces CO_2 and H_2O according to the unbalanced chemical equation below.
$CH_3OH(l) + O_2(g) \rightarrow CO_2\,(g) + H_2O(g)$



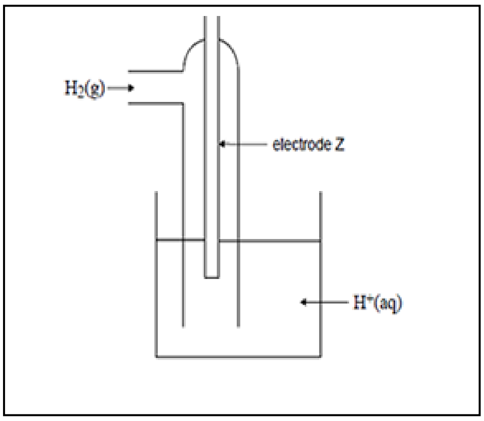
a) Using the template shown on the right
   i. label the anode and cathode
   ii. indicate where the methanol reacts and also indicate where the oxygen enters the fuel cell.
   iii. Assuming an acidic electrolyte is used write the half equation that occurs at the anode
   $H_2O(l) + CH_4O(l) \ \text{->}\ CO_2(g) + 6H^+(aq) + 6e$
   the cathode
   $4e + 4H^+(aq) + O_2(g) \ \text{->}\ 2H_2O(l)$
   iv. Assuming an alkaline electrolyte is used write the half equation that occurs at the anode
   $6OH^-(aq) + CH_4O(l) \ \text{->}\ CO_2(g) + 5H_2O(l) + 6e$
   the cathode
   $4e + 2H_2O(l) + O_2(g) \ \text{->}\ + 4OH^-(aq)$

   v. Discuss how the electrodes of a fuel cell differ to those of a normal galvanic cell.
   Unlike some galvanic cells the electrodes of a fuel cell are not used up. The electrodes of a fuel cell are porous to allow the flow of reactants through them to react with ions in the electrolyte and also as catalysts for oxidation and reduction reactions. Porous electrodes also provide greater surface area for reaction which increases the size of the current. These electrodes also serve to separate the reactants. Electrodes of a fuel cell also serve to separate the gas compartments from each other.
   vi. Can a fuel cell be recharged? Explain your answer.
   No. Products are removed from the fuel cell and reactants constantly supplied

b) Some methanol may also be used for electric power for electronic equipment. This can be provided through the fuel cell with an acidic electrolyte, whose cell reaction is identical to the equation given above. An alternative way of generating electricity from methanol is to use it as the fuel for an internal combustion engine driving a generator. Suggest one important reason why the fuel cell would be better than the generator for this purpose.
Less energy conversions and hence less energy lost as heat.

2) The diagram on the right represents a $H^+(aq)/H_2(g)$ half cell for the reaction

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



a. Identify an appropriate material for electrode Z and give reasons.

Graphite or platinum

b. For this half cell to be a **standard** half cell, at what temperature must it operate?

25^oC

c. What should the pH be, for it to operate at standard conditions.

pH = 0 (1M H^+solution)

d. A galvanic cell consists of the following half cells which have been set up under standard conditions.

. Half cell 1: the $H^+(aq)/H_2(g)$ half cell described in part a.

. Half cell 2: a cadmium (Cd) electrode in a solution containing $Cd^{2+}(aq)$

After some time, the pH in half cell 1 has increased. Use this information to identify the species in this galvanic cell which is the stronger reductant and explain how you reached this conclusion.

Since the pH is increasing the $[H^+]$ is decreasing hence the half reaction

$2H^+(aq) + 2e \rightarrow H_2(g)$ is taking place.

$Cd^{2+}(aq) + 2e \rightarrow Cd(s)$ is also taking place and hence Cd is the strongest reductant present. Both reactions appear in the order given below on the E^o table.

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

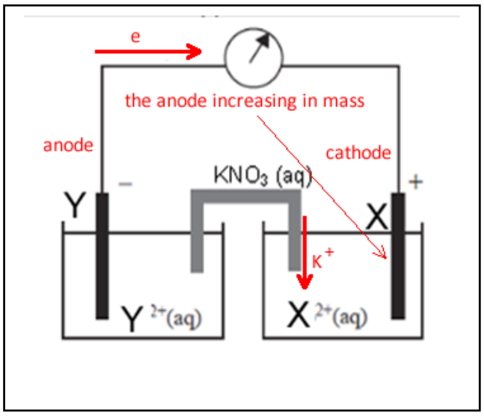
$Cd^{2+}(aq) + 2e \rightarrow Cd(s)$

Cd is the stronger of the two reductants (H_2 and Cd) present.

3) Consider the galvanic cell on the right and the information below.

$Y^{2+}(aq) + 2e \rightarrow Y(s)$ $E^o = 1.01V$

$X^{2+}(aq) + 2e \rightarrow X(s)$ $E^o = 2.36V$



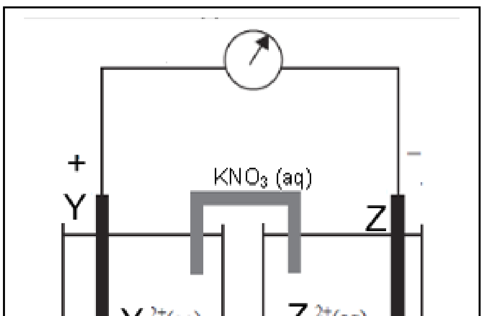
a) Indicate the

i. the direction of electron flow.

ii. anode and cathode

iii. the electrode which is increasing in mass as the cell discharges.

iv. the direction of positive ion flow



v. The following two half cell were set up. Indicate the relative position of the half cell equation below on the E° table.

$X^{2+}(aq) + 2e \rightarrow X(s)$ $E^o = 2.36V$

$Y^{2+}(aq) + 2e \rightarrow Y(s)$ $E^o = 1.01V$

$Z^{2+}(aq) + 2e \rightarrow Z(s)$ $E^o < 1.01V$