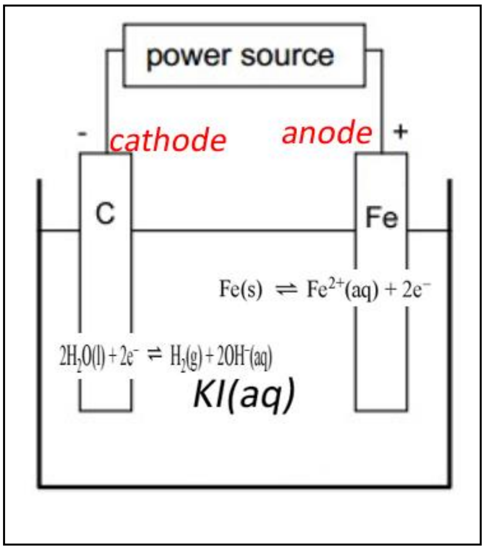
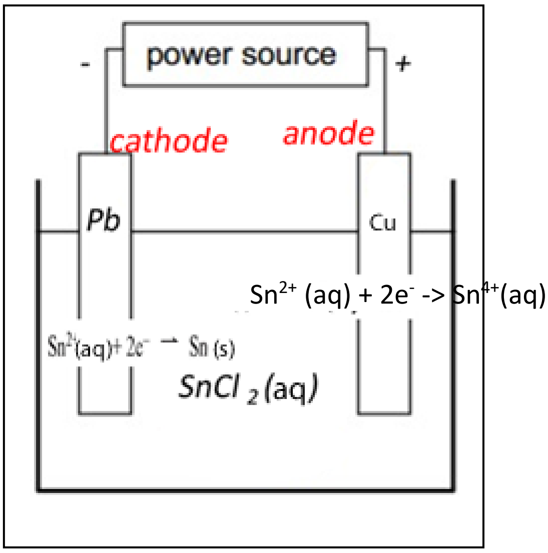
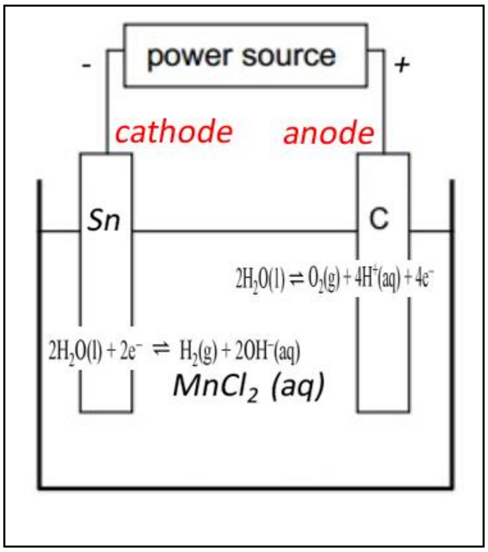
Revision 5

- Equilibrium and electrolytic cells.

1) Consider the diagram shown on the right of a set of electrolytic cells at SLC. For each cell:
    - Clearly label the cathode and anode
    - Give the products formed at each electrode immediately after the current starts to flow.
    - Write a balanced equation for the half reaction occurring at each electrode.



2) A gas cylinder of volume 20.0 L is filled with $NH_3$ gas at an initial temperature of 30.0 °C and pressure of 2.21 atm . Ammonia reacted according to the equation below until equilibrium was established.

$2NH_3\ (g) \rightleftarrows 3H_2(g) + N_2(g)\ \Delta H = +92$ kJ/mol

a) Calculate the mol of ammonia gas initially present in the cylinder.

*PV = nRT*

*=> (224 Kpa X 20.0L ) / (8.31 X 303K) = n*

*=> 1.78 mol of $NH_3$*

b) After equilibrium was established the gas mixture was analysed and found to contain 0.400 mol of $N_2$ gas. Calculate the:

- The amount of mol of the following substances at equilibrium.

  $NH_3$

  Since 0.400 mol of $N_2$ gas was present, according to the stoichiometric ratio given by the equation above twice as much $NH_3$ must have reacted (0.800 mol)

  => 1.78 – 0.800 = *0.980 mol of $NH_3$ is present.*

  $H_2$

  *If 0.400 mol of $N_2$ is formed then 3 times as much $H_2$ is also formed according to the stoichiometric ratio*

  *=> 1.20 mol*

- value of the $K_c$ for the system at equilibrium

  *$[N_2]$ = 0.400 / 20.0 = 0.0200 M*

  *$[H_2]$ = 1.20 / 20.0 = 0.0600 M*

  *$[NH_3]$ = 0.980 /20.0 = 0.0490*

  *=> $(0.0600)^3(0.0200) / (0.0490)^2 = 1.80 \times 10^{-3}\ M^2$*

- Calculate the total number of mol of gas particles in the cylinder

  *0.979 + 1.20 + 0.400 = 2.58*

- calculate the total pressure exerted by the gas mixture at equilibrium.

  *PV = nRT*

  *=> P = 2.58 X 8.31 X 303 / 20.0 = 325 kPa*

3) Carbonic acid dissolves in water to produce hydrogen ions and bicarbonate ions which play a vital role in buffering the blood from swings in pH. The reaction is shown below. At a given temperature the $K_c$ for the reaction is $2.30 \times 10^{-2}$ M.

$H_2CO_3\ (aq) \rightleftarrows H^+\ (aq) + HCO_3^-\ (aq)$

Calculate the pH of the solution, at this temperature, if the $[H_2CO_3]$ is $2.24 \times 10^{-4}$ M

$[H^+][HCO_3^-] / [H_2CO_3] = 2.3 \times 10^{-2}$ M.

=> $[H^+][HCO_3^-] / 2.24 \times 10^{-4}\ M = 2.3 \times 10^{-2}$ M.

Since $H^+$ and $HCO_3^-$ are produced equally we can write

=> $[H^+]^2 = 2.24 \times 10^{-4}\ M \times 2.30 \times 10^{-2}$ M

*=> $5.152 X 10^{-6} = [H^+]^2$ => $[H^+]$ =* $2.27 X 10^{-3}$ M

pH =$-\log_{10}$ 0.00227 = 2.64

4) In an experiment, 2.0 mol of pure phosgene, $COCl_2$, is placed in a 2.0 L flask where the following reaction takes place.

$COCl_2(g) \rightleftarrows CO(g) + Cl_2(g)$ $K_c = 2.10 \times 10^{-8}$ M

It can be assumed that, at equilibrium, the amount of unreacted $COCl_2$ is approximately equal to 2.0 mol.

a) Explain why this assumption is justified.

*Consider the $K_c$ value for this reaction, of $2.10 \times 10^{-8}$ M. At the given temperature, it is extremely low indicating that negligible amount of $COCl_2$ reacts.*

b) Calculate the amount, in mol, of $Cl_2$ (g) present at equilibrium. Give the answer to the right number of significant figures.

*According to the stoichiometry CO and $Cl_2$ are produced in equal amounts. This fact coupled with the assumption that negligible $COCl_2$ reacts can be used to write the following expression.*

*=> $[Cl_2]^2 / [COCl_2] = 2.10 \times 10^{-8}$ M*

*=> $[Cl_2]^2 = [2.0/2.0] X 2.10 \times 10^{-8}$ M => $1.0 X 2.10 \times 10^{-8}$ M*

*=> $[Cl_2] = 1.45 X 10^{-4}$*

*=> $n_{chlorine\ gas} = C X V = 1.45 X 10^{-4} X 2.0 = 2.9 X 10^{-4}$ mol*

c) Jack was explaining to a fellow student how to go about solving b) above. " Assume we have negligible $COCl_2$ reacting and also assume that equal amounts of CO and $Cl_2$ are produced." Is this strictly correct? Explain

*No.*

*We can assume that negligible $COCl_2$ reacts due to the small $K_c$ value, however, the production of equal amounts of CO and $Cl_2$ is not an assumption but given by the stoichiometry $COCl_2(g) \rightleftarrows CO(g) + Cl_2(g)$*