Friday Worksheet 1 **Name: …….**

Secondary cells

1) The cell reaction when a 12 V car battery releases energy is given by the equation below.

$$Pb(s) + PbO_2(s) + 4H^+(aq) + 2SO_4^{2-}(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$$

   a) When the battery is being **recharged**, write the equation to the reaction that occurs at the negative electrode is

   $PbSO_4(s) + 2e^- \rightarrow Pb(s) + SO4^{2-}(aq)$

   b) Write the reaction that occurs at the cathode when the battery is discharging.

   c) What voltage should be used to recharge the battery?

   A voltage greater than the discharge voltage,12V, is needed for recharge.

2) The rechargeable nickel-cadmium cell is used to power small appliances such as portable computers. When the cell is being used, the electrode reactions are represented by the following equations.

$$NiO_2(s) + 2H_2O(l) + 2e. \Rightarrow Ni(OH)_2(s) + 2OH^-(aq)$$

$$Cd(s) + 2OH^-(aq) \Rightarrow Cd(OH)_2(s) + 2e.$$

   Consider the following statements

   I cadmium is deposited on the negative electrode

   II the pH of the electrolyte increases

   III the direction of electron flow in the external circuit is from the anode to the cathode

   IV the negative electrode loses mass.

   V the pH around the cathode increases.

   a) Which of the above occurs during the **recharging** of the nickel-cadmium cell?

I cadmium is deposited on the negative electrode

*When the cell is discharging the half cell reaction, $Cd(s) + 2OH–(aq \Rightarrow Cd(OH)_2(s) + 2e–$, is an oxidation reaction negative anode of the cell. During the recharging phase, this reaction must be reversed to become a reduction reaction. Thus the electrode will be then a cathode and a negative electrode with the half reaction: $Cd(OH)_2(s) + 2e– \Rightarrow Cd(s) + 2OH–(aq)$, depositing cadmium. Therefore, **Option I** is correct.*

II the pH of the electrolyte increases

*During the **recharge** phase the following reactions take place.*

At the negative cathode ---- $Cd(OH)_2(s) + 2e \Rightarrow Cd(s) + 2OH^-(aq)$

At the positive anode ----- $Ni(OH)_2(s) + 2OH^-(aq) \Rightarrow NiO_2(s) + 2H_2O(l) + 2e$

It is obvious that the same amount of OH^- ions are produced and consumed and hence no chanage in the pH of the electrolyte is expected..

III the direction of electron flow in the external circuit is from the anode to the cathode

During recharge the positive electrode, the electrode where electrons are pulled out of by the power source, is the anode and hence electrons flow from the anode to the cathode. Option III is correct.

IV the negative electrode loses mass.

During recharge the negative electrode is the cathode where reduction takes place. The following reaction takes place at the cathode during recharge

At the negative cathode ---- $Cd(OH)_2(s) + 2e \Rightarrow Cd(s) + 2OH^-(aq)$

The electrode loses mass as $Cd(OH)_2$ goes to CD. Option IV is correct.

V the pH around the cathode increases in pH.

During recharge the $[OH^-]$ increases, therefore, pH increases. Option V is correct.

3) A rechargeable cell, used in laptop computers, contains a metal alloy (designated M) which has hydrogen atoms adsorbed on its surface, and nickel in the form of NiO(OH)(s) and Ni(OH)2(s). The half reactions, written as reduction reactions, as they would appear on the electrochemical series, are

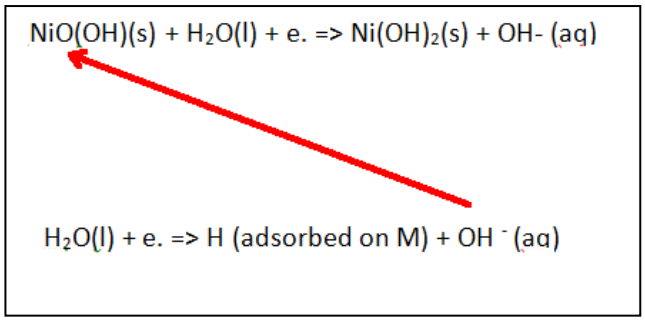
$H_2O(l) + e. \Rightarrow H$ (adsorbed on M) + $OH.^-$ (aq)

$NiO(OH)(s) + H_2O(l) + e. \Rightarrow Ni(OH)_2(s) + OH^-$ (aq)

a) While this cell is generating electricity, the metal alloy acts as the negative electrode. When this cell is discharging :

i. what species acts as the oxidant?

The negative electrode is where oxidation takes place and is where the strongest reductant is.



$NiO(OH)(s) + H_2O(l) + e \Rightarrow Ni(OH)_2(s) + OH.^-$ (aq)

NiO(OH) is the oxidant

ii. what happens to the pH of the electrolyte ? *No change. One OH^- used in reduction and one OH^- produced in oxidation.*

Anode (-) -. H (adsorbed on M) + $OH.^-$ (aq) => $H_2O(l) + e$

Cathode(+) - $NiO(OH)(s) + H_2O(l) + e \Rightarrow Ni(OH)_2(s) + OH^-$ (aq)

b) When recharging what is produced at the electrode connected to the positive terminal of the power source?

Cathode (-) ---. H (adsorbed on M) + OH^- (aq)

Anode(+) --- $NiO(OH)(s) + H_2O(l)$