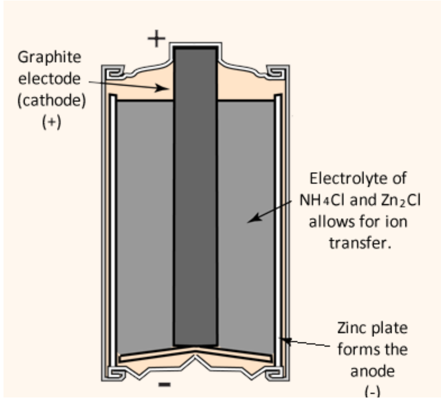
Friday Worksheet 2 **Name: ………………**

Secondary and primary cells revision

Consider the diagram of a carbon-zinc cell, pictured on the right.
This was the first small scale source of electrical energy.
An electrolyte composed of a moist paste of zinc chloride and ammonium chloride allows for ion transfer and as such plays the same role as the salt bridge.



1) Although the overall cell reaction for this battery is complex we can break it down into two major reactions.

i. Zn / Zn^{2+}

ii. $MnO_2(s) / Mn_2O_3(s)$

a) Write the balanced equation for the reaction occurring at the anode. States not required.
$Zn(s) \rightarrow Zn^{2+}(aq) + 2e$

b) Write the balanced equation for the reaction occurring at the cathode. States not required.
$2H^+(aq) + 2e + 2MnO_2(s) \rightarrow Mn_2O_3(s) + H_2O(l)$

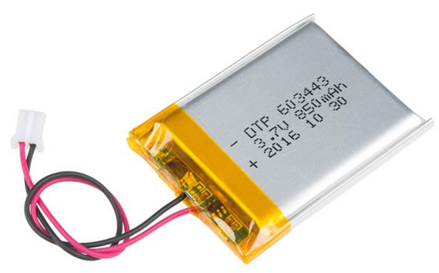
c) The alkaline version of this battery lasts five times longer.
One of the half-cell reactions is $Zn(s) + 2OH^-(aq) \rightarrow Zn(OH)_2(s) + 2e$ the other still involves MnO_2 forming Mn_2O_3. Write the balanced half-equation for the reaction of MnO_2 to Mn_2O_3.
$2MnO_2(s) + H_2O (l) + 2e \rightarrow Mn_2O_3 (s) + 2OH^-(aq)$

d) What is the change in pH surrounding the cathode ? Explain
The following reaction occurs at the cathode $2MnO_2(s) + H_2O (l) + 2e \rightarrow Mn_2O_3 (s) + 2OH^-(aq)$ therefore OH^- is produced and hence the pH will increase.

e) What is the overall change in the pH of the electrolyte? Explain
No change. The same amount of OH^- ions are produce as are used.

Secondary cells are cells that can be recharged.
To recharge a cell, electrical energy is provided to convert the products back into reactants. For this to happen the products must be in contact with the electrode. This is done by connecting the cell to a charger, a source of electrical energy, which delivers a voltage greater than the voltage supplied by the cell. When recharging a battery the overall energy conversion is electrical into chemical.

2) The lithium-ion battery is a secondary cell that is now widely used in portable electronic devices. In these type of batteries, lithium ions (Li^+) move through a special non-aqueous electrolyte between the two electrodes. Both electrodes are made up of materials that allow the absorption of lithium ions whilst allowing for their free movement in and out of their lattice structure.
The anode consists of LiC_6, where lithium is embedded in the graphite structure, whilst lithium cobalt oxide ($LiCoO_2$) is commonly used as the material in the cathode. The reaction at the anode during discharge is $LiC_6 \rightarrow Li^+ + e + C_6$
Whilst the reaction at the cathode during discharge is
$CoO_2 + Li^+ + e \rightarrow LiCoO_2$
When the cell discharges, Li^+ ions move out of the anode and move towards the cathode where they enter the structure of the cathode and are captured as $LiCoO_2$.



a. During recharge, what is the polarity of the graphite electrode?

Since the graphite electrode is the anode it is negative during discharge and during recharge.

b. Write the half-equation for the reaction that occurs at the anode of a lithium-ion battery when the cell is **recharging.**

$LiCoO_2 \rightarrow CoO_2 + Li^+ + e$

c. In the past, batteries with metallic lithium electrodes were used but presented safety issues, as a result, research moved to find ways to remove the safety concerns and developed batteries in which, only lithium compounds which are able to freely accept and release lithium ions are present. Explain why the early lithium batteries were a safety risk and justify your answer with the use of appropriate equations.

Students should use the electrochemical series to answer this question.

According to the electrochemical series Lithium metal is a powerful reductant, which is why it is used to batteries. However it can react with atmospheric water to produce hydrogen gas which is explosive

Students should have stated.

i. The relative positions of H_2O and Li on the electrochemical series and stated the spontaneous reaction and also given the appropriate half equations and overall equation.

$2H_2O(l) + 2e \rightarrow H_2(g) + 2OH^-(aq)$ $E^o = -0.83$

$Li^+(aq) + e \rightarrow Li(s)$ $E^o = -3.04$

Overall reaction => $2H_2O(l) + 2Li(s) \rightarrow H_2(g) + + 2OH^-(aq) + 2Li^+(aq)$

ii. State the explosive nature of hydrogen

d. Potassium ion batteries also exist and just like lithium ion batteries they too must be tightly sealed to prevent moisture entering the cell. Give a reason as to why lithium ion as opposed to potassium ion batteries are more popular today.

Lithium is a lighter metal and hence has a greater energy density.