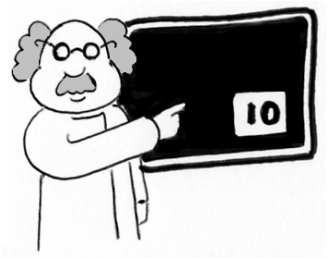


STARTER FOR 10...

12.5. Applications of electrochemical cells

Technically a **battery is two or more simple cells connected together**. However in everyday speech we rarely make the distinction.

There are a wide variety of batteries available today. The table below shows some details of the chemistry involved in just a few.

Battery type	Half equations with electrode potentials		E_{cell} / V
Zinc/carbon	$Zn^{2+}(aq) + 2\,e^- \rightleftharpoons Zn(s)$	$E \approx -0.8$ V	
	$2\,NH_4^+(aq) + 2\,e^- \rightleftharpoons 2\,NH_3(g) + H_2(g)$	$E \approx +0.7$ V	.....
Nickel/cadmium	$Cd(OH)_2(s) + 2\,e^- \rightleftharpoons Cd(s) + 2\,OH^-(aq)$	$E \approx -0.8$ V	
	$NiO(OH)(s) + H_2O(l) + 1\,e^- \rightleftharpoons Ni(OH)_2(s) + OH^-(aq)$	$E \approx +0.5$ V	.....
Lead-acid	$PbSO_4(s) + 2\,e^- \rightleftharpoons Pb(s) + SO_4^{2-}(aq)$	$E \approx -0.35$ V	
	$PbO_2(s) + 4\,H^+(aq) \rightleftharpoons PbSO_4(s) + 2\,H_2O(l) + SO_4^{2-}(aq) + 2\,e^-$	$E \approx +1.70$ V	.....
Fuel cell	$2\,H^+(aq) + 2\,e^- \rightleftharpoons H_2(g)$	$E \approx 0.0$ V	
	$4\,H^+(aq) + O_2(g) + 4\,e^- \rightleftharpoons 2\,H_2O(l)$	$E \approx +1.2$ V	.....

1. Complete the table above by calculating the e.m.f. for each of the different cell types. (4 marks)

2. Consider the nickel/cadmium cell in more detail.

(a) Identify the element which undergoes a change in oxidation state at the positive electrode and state the oxidation state change.

.....(2 marks)

(b) Write the conventional representation of the cell.

.....(2 marks)

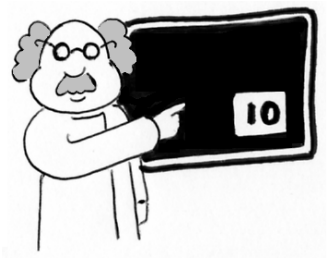
(c) The nickel-cadmium cell is rechargeable. Write an equation for the overall reaction that occurs when the battery is being **recharged**.

.....

.....(1 mark)

(d) Nickel/cadmium cells must be carefully disposed of. Suggest one reason why.

.....(1 mark)



STARTER FOR 10...

12. Redox equilibria answers

12.5. Applications of electrochemical cells

1.

Battery type	Half equations with electrode potentials		E_{cell} / V
Zinc/carbon	$Zn^{2+}(aq) + 2\,e^- \rightleftharpoons Zn(s)$ $2\,NH_4^+(aq) + 2\,e^- \rightleftharpoons 2\,NH_3(g) + H_2(g)$	$E \approx -0.8$ V $E \approx +0.7$ V	± 1.5
Nickel/cadmium	$Cd(OH)_2(s) + 2\,e^- \rightleftharpoons Cd(s) + 2\,OH^-(aq)$ $NiO(OH)(s) + H_2O(l) + 1\,e^- \rightleftharpoons Ni(OH)_2(s) + OH^-(aq)$	$E \approx -0.8$ V $E \approx +0.5$ V	± 1.3
Lead-acid	$PbSO_4(s) + 2\,e^- \rightleftharpoons Pb(s) + SO_4^{2-}(aq)$ $PbO_2(s) + 4\,H^+(aq) \rightleftharpoons PbSO_4(s) + 2\,H_2O(l) + SO_4^{2-}(aq) + 2\,e^-$	$E \approx -0.35$ V $E \approx +1.70$ V	± 2.05
Fuel cell	$2\,H^+(aq) + 2\,e^- \rightleftharpoons H_2(g)$ $4\,H^+(aq) + O_2(g) + 4\,e^- \rightleftharpoons 2\,H_2O(l)$	$E \approx 0.0$ V $E \approx +1.2$ V	± 1.2

(4 marks)

2. (a) Nickel, from +3 in NiO(OH) to +2 in $Ni(OH)_2$ *(2 marks)*

(b) $[2\,OH^-(aq) + Cd(s)]$, $Cd(OH)_2(s) \parallel [NiO(OH)(s) + H_2O(l)]$, $[Ni(OH)_2(s) + OH^-(aq)]$

(2 marks, 1 for each side correct)

(c) $Cd(OH)_2(s) + 2\,Ni(OH)_2(s) \rightarrow 2\,NiO(OH)(s) + 2\,H_2O(l) + Cd(s)$ *(1 mark)*

(d) Nickel / cadmium are both toxic metals..... *(1 mark)*