CELLS AND BATTERIES 27 AUGUST 2013

Lesson Description

In this lesson, we:

- Show that a spontaneous reaction can produce energy.
- Identify the parts of a cell.
- Calculate the amount of charge and energy stored in a cell.
- Distinguish between primary and secondary cells.

Key Concepts

Cells operate using a spontaneous REDOX reaction

Since cells work on REDOX reactions:

- One chemical loses electrons.
- One chemical gains electrons.
- Let's make the electrons work along the way!

Lets make a cell using copper, zinc and some sulfuric acid.

The species are:

- Cu metal
- Zn metal
- H^+ ions
- SO_4^{2-} ions

$Zn^{2+} + 2e^-$	$\rightleftharpoons$	Zn	$-0,76$
$Cr^{3+} + 3e^-$	$\rightleftharpoons$	Cr	$-0,74$
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	Fe	$-0,44$
$Cr^{3+} + e^-$	$\rightleftharpoons$	Cr^{2+}	$-0,41$
$Cd^{2+} + 2e^-$	$\rightleftharpoons$	Cd	$-0,40$
$Co^{2+} + 2e^-$	$\rightleftharpoons$	Co	$-0,28$
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	Ni	$-0,27$
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	Sn	$-0,14$
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	Pb	$-0,13$
$Fe^{3+} + 3e^-$	$\rightleftharpoons$	Fe	$-0,06$
$2H^+ + 2e^-$	**$\rightleftharpoons$**	**$H_2(g)$**	**0,00**
$S + 2H^+ + 2e^-$	$\rightleftharpoons$	$H_2S(g)$	$+0,14$
$Sn^{4+} + 2e^-$	$\rightleftharpoons$	Sn^{2+}	$+0,15$
$Cu^{2+} + e^-$	$\rightleftharpoons$	Cu^+	$+0,16$
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(g) + 2H_2O$	$+0,17$
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	Cu	$+0,34$

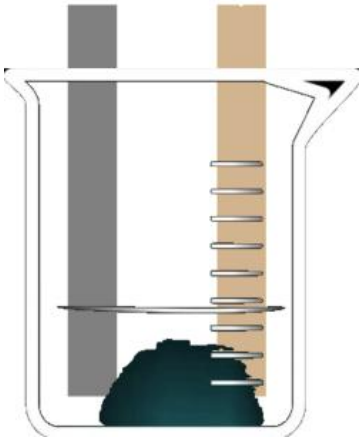
Example

Write out the correct half-reactions.

The parts of the cell are:

- Anode
- Cathode
- Electrolyte
- External circuit

Label and complete the diagram shown here.



Calculate the Charge and Energy Stored in a Cell

$$Q = I\Delta t$$

Cell capacity (Ah)

Current (A)

Time (h)

$$W = VQ$$

Cell energy (Wh)

Cell emf (V)

Cell capacity (Ah)

Example

A battery is marked with 12 V 7Ah written on the side. Calculate the energy stored inside.

Terminology

Anode

Electrode where oxidation takes place.

Cathode

Electrode where reduction takes place.

Primary Cell

A cell which can only be used once.

Secondary Cell

A cell which can be recharged.

Demonstration

Try placing two different metals in vinegar and testing the voltage produced.

The difference in the metals allows for a flow of electrons.

You can even make your own battery by placing alternating stack on top of one another!

Questions

Question 1

(DOE Nov 2012, Question 10)

The following half-reactions take place when a non-rechargeable alkaline cell is in use:

$$Zn(s) + 2OH^-(aq) \rightarrow ZnO(s) + H_2O(\ell) + 2e^- \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

$$MnO_2(s) + 2H_2O(\ell) + 2e^- \rightarrow Mn(OH)_2(s) + 2OH^-(aq) \ldots\ldots(2)$$

a.) Write down the general name used for non-rechargeable cells. (1)
b.) Which ONE of the above equations (1 or 2) represents the half-reaction that takes place at the cathode? Give a reason for your answer. (2)
c.) Give a reason why the cell 'dies' after delivering current for a while. (1)
d.) The emf of the alkaline cell is 1,5 V. The maximum electrical work that can be done by this cell is 3×10^4 J.

Calculate the:

i. Cell capacity of this cell in A·h (4)
ii. Maximum constant current that this cell can deliver for 20 hours (3)

Links

- http://www.mindset.co.za/learn/xtra
- http://www.education.gov.za/Examinations/PastExamPapers/tabid/351/Default.aspx
- http://phet.colorado.edu