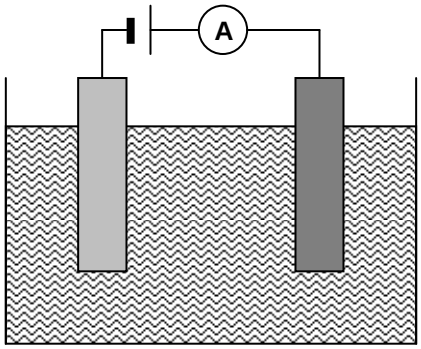
ELECTRIC CURRENT IN LIQUIDS

1. Electrolyte and electrolysis

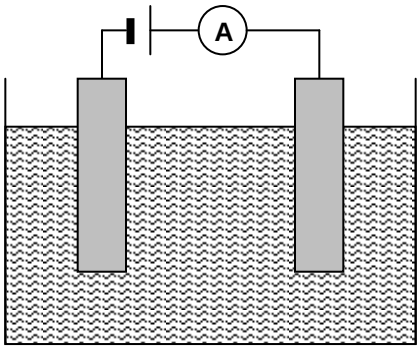
electrolyte = liquid which can conduct an electric current
(must contain ions = acids, bases or salts dissolved or melted)
electrolysis = process when the current passes through the electrolyte and substances are liberated, deposited or dissolved

i) $CuSO_4$ in water, C cathode (-), Cu anode(+) – optional



- Cu deposited on cathode
- Cu anode dissolved
- concentration of Cu SO_4 doesn't change
- used for electroplating, refining metals
- finish the figure – write chemical reactions

ii) H_2SO_4 in water, Pt electrodes



- H_2 liberated on cathode
- O_2 liberated on anode
- water used = electrolysis of water
- used to produce O_2 and H_2 – expensive
- finish the figure – write chemical reactions

http://www.youtube.com/watch?v=m8n-9Pgo-AA&NR=1
http://kabinet.fyzika.net/dilna/prezentace/vyukove-prezentace.php

Hoffman's voltameter

Use different resources to find and sketch the construction of the device.

Oxygen is liberated on anode/cathode

Hydrogen is liberated on anode/cathode

When the same charge passed through the liquid, state the ratios:

$$\frac{m(O_2)}{m(H_2)} =$$

$$\frac{V(O_2)}{V(H_2)} =$$

Sketch

2. Faraday's Laws

are about the mass m of substances liberated, deposited or dissolved during electrolysis

- each molecule needs some electrons to accept or lose to be lib. dep. or diss. – their number = ν
- N = number of molecules dep. lib. or diss. when Q has passed

$$N = \frac{Q}{\nu e}$$

- m_0... mass of one molecule
  M_m...molar mass
  N_A... Avogadro number = number of particles in one mole

$$m = N \cdot m_0 = \frac{Q}{\nu e}\frac{M_m}{N_A} = \frac{M_m}{F\nu}Q$$

$F = eN_A$ ... Faraday's Constant $\approx$ the total charge of one mole of monovalent ions or electrons

F = 9.65x10^4 C·mol^{-1}

1st Faraday's Law: $m = AQ = AIt$

The mass of a substance lib. dep. or diss. during electrolysis is directly proportional to the charge passed.

A or ECE ... electrochemical equivalent – material constant $\approx$ mass lib. dep. or diss. when 1 C has passed the liquid

$[A] = \text{kg} \cdot \text{C}^{-1}$

substance	Mg^{+2}	Cr^{+3}	Cu^{+2}	Ni^{+2}	Fe^{+2}	Fe^{+3}	H^+	O^{-2}	Cl^-	Zn^{+2}	Ag^+	Au^{+3}	Na^+
A 10^{-6}kgC^{-1}	0.126	0.180	0.329	0.304	0.289	0.193	0.010	0.083	0.367	0.339	1.118	0.681	0.223

2nd Faraday's Law: $A = \frac{M_m}{F\nu}$

- how to calculate ECE of any substance

Questions:

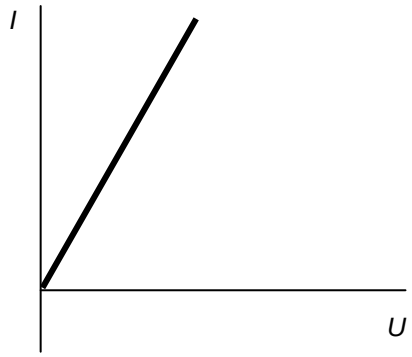
1. Calculate the electrochemical equivalent of hydrogen, copper, cobalt, zinc, silver, magnesium.
2. How long should the current 100 mA pass through a solution of $CoCl_2$ so that 20 mg of cobalt are deposited?
3. Compare the masses of hydrogen and copper that would be deposited when the same charge passed through the solutions of H_2SO_4 and $CuSO_4$.
4. A current passed through a solution of H_2SO_4 for 15 minutes and 10 mg of oxygen were liberated. Calculate a) the electrochemical equivalent of oxygen b) the value of the current.
5. Two identical vessels for electrolysis A and B contain the same volume of solution of $ZnSO_4$. The concentration in vessel A is bigger than the concentration in vessel B. The vessels are connected in parallel to the source of d.c. a) Is the mass of copper deposited during the same time in A different from the mass deposited in B? b) Explain c) What would differ if we connect the vessels in series?

L5/ 228-239, 240a, x240b-242

Characteristic of an electrolyte

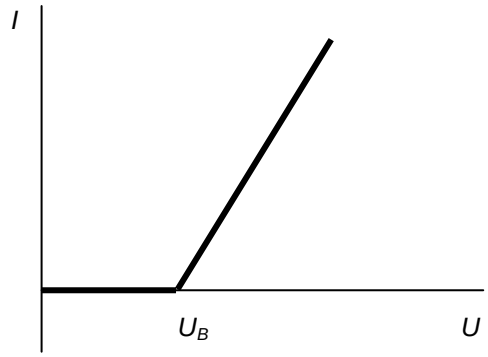
shows how the current passing through the electrolyte varies with p.d. between the electrodes

$CuSO_4$ and Cu, C electrodes



$$I = \frac{U}{R}$$

acidified water and Pt electrodes



$$I = \frac{U - U_B}{R}$$

U_B ... back e.m.f.

R is directly/indirectly proportional to concentration of ions, because .....

R is directly/indirectly proportional to temperature, because .....

R is directly/indirectly proportional to distance between the electrodes , because .....

R is directly/indirectly proportional to the depth (area) of the electrodes, because .....

The characteristics differ because of different current/different material of electrodes/bubbles of neutral gas liberated/different temperature

choose correct statement

3. Simple cells and accumulators

- convert chemical energy into electrical energy
- consist of two different metals or a metal and carbon
- e.m.f. depends on the nature and concentration of the chemicals used – see chemistry

$C = It = Q$ ... capacity of an accumulator = total charge stored
$[C] = \mathrm{A} \cdot \mathrm{h} = 3600\ \mathrm{A} \cdot \mathrm{s} = 3600\ \mathrm{C}$ (coulombs)

Primary (voltaic) cells

cannot be recharged

Volta cell - use different resources to find

materials of electrodes

electrolyte

voltage

advantages/disadvantages

http://www.chembook.co.uk/chap11.htm

Other types of simple cells have different materials of electrodes and mainly electrolyte, which can even be divided by a semi-permeable membrane. All the improvements were made to minimize the size and to enable the cell to supply almost the same voltage during the longest possible lifetime.
http://www.daviddarling.info/encyclopedia/N/AE_NAS_battery.html
http://www.ngk.co.jp/english/products/power/nas/principle/index.html

Examples:

Secondary cells

can be recharged = accumulators (of charge – electric energy)

Lead-acid – the commonest, e.m.f. about 2 V, in cars – 6 in series = 12 V, R_i about 0.01 Ω
http://kabinet.fyzika.net/dilna/prezentace/vyukove-prezentace.php
Use the presentation above and other resources to answer the following questions:

What is the original material of electrodes?

How do we get two different electrodes from the same metal?

What is the electrolyte?

What are the changes of the electrodes during charging?

What are the changes of the electrolyte during charging?

Which process is electrolysis – charging or discharge?

Nickel-iron (nife), nickel-cadmium (nicad), nickel-metal hydride (NiMH), lithium-ion – other types, use different resources to find for some of them:

materials of electrodes and electrolyte

capacity

size

use

http://electronics.howstuffworks.com/battery5.htm

Answers:
1. $A(\mathrm{Co}) = 3.057\times10^{-7}\ \mathrm{kg\cdot C^{-1}}$
2. 654 s
3. 0.03
4. a) $8.3\times10^{-8}\ \mathrm{kg\cdot C^{-1}}$ b) 134 mA