FARADAY'S LAWS AND ELECTROLYSIS

Faraday's Laws explain the relationship between the amount of electricity used and the quantity of chemical charge it produces.

Faraday's First Law

This law states that the mass of substance liberated (deposited at or dissolved from) an electrode during electrolysis is proportional to the quantity of electricity passed through the electrolyte.

Faraday's Second Law

This law states that when the same quantity of electricity is passed through solutions of different electrolytes, the relative numbers of moles of the elements liberated are inversely proportional to the charges on the ions of each of the elements respectively.

In summary, the number of moles of an element liberated during electrolysis depends on:

i. The time of passing of the current
ii. The magnitude of the current passed
iii. The charge on the ion of the element

N.B. Quantity of electricity is measured in coulombs (C).
Quantity of electricity = Current (Amperes) × Time (Seconds)

A specific quantity of electricity is known as a Faraday (F). This is equal to 96500 C. 96500 C is equal to one mole of electrons.

1 Faraday (F) will liberate 1 mole of a monovalent ion.
E.g. $Na^+ + e^- \rightarrow Na$

1 F liberates ½ mole of a divalent ion.
1 F liberates 1/3 mole of a trivalent ion.

2 F will liberate 1 mole of a divalent ion
E.g. $Mg^{2+} + 2\ e^- \rightarrow Mg$

3 F will liberate 1 mole of a trivalent ion.

2 F will liberate 1 mole chlorine gas
E.g. $2\ Cl^- - 2\ e^- \rightarrow Cl_2$

4 F will liberate 1 mole oxygen gas
E.g. $2O^{2-} - 4\ e^- \rightarrow O_2$

QUESTIONS

Try these:

1. How many Faradays are needed to produce:
a) 2.7 g of Al
b) 6.0 g of Mg
c) 10 g of hydrogen gas
d) 71 g of chlorine gas

2. How many coulombs are needed to produce
a) 5 g of Ca
b) 7.8 g of K
c) 11.5 g of Na
d) 48 g of oxygen gas

Example:
A current of 0.25 A was passed through molten $PbCl_2$ for 300 seconds using inert electrodes.

a) What element is liberated at the anode?
b) What element is liberated at the cathode?
c) Give ionic equations for the reactions occurring at each of the electrodes.
d) Determine the quantity of electricity passed during this experiment.
e) Determine the volume of gas produced at RTP.

Solutions:

a) Chlorine gas

b) Lead

c) At the cathode: $Pb^{2+} + 2\ e^- \rightarrow Pb$
At the anode: $2\ Cl^- - 2\ e^- \rightarrow Cl_2$

d) $Quantity\ (Q) = Current\ (I) \times Time\ (t)$

$= 0.25\ A\ \times 300\ s = 75\ C$

e) At RTP, 1 mole contains 24 dm^3 of gas.

2 F (2 × 96500 C) will liberate 1 mole of Cl_2 gas

$$193{,}000\ C\ will\ liberate\ 24\ dm^3\ of\ Cl_2$$

$$\therefore 75\ C\ will\ liberate\ \frac{75\ C}{193{,}000\ C} \times 24 = 0.0093\ dm^3$$