Ministry of Higher Education and Scientific Research

Al-Muthanna University

College of Science

وزارة الــتعليم الــعالــي والــبحث الــعلمي

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Electrochemistry

Lecture (2)

Stage 3

Prof. Hassan Sabih

Faraday's Laws of Electrolysis

In 183-4 , Michael Faraday studied electrolysis and came up with
Two laws govern the process of electrical analysis .
Faraday was the first to discover the quantity of the current used.
The chemical tide that occurs at the electrodes during electrolysis is extended .

First Law :

It states :

" is proportional to the amount of material m (g) that is experienced by the chemical g (oxidation or sister of the g) (Melting, Sedimentation, or Mounting GA G)) At the poles proportional to the quantity of
Electricity (Q) that passes into an electrolytic or molten solution. "
The amount of electricity (Q) is measured in coulomb , which is the number of amperes (intensity).
Current) passing through in the unit of time .

Formulation of the first law mathematically:

The amount of substance that occurs at the electrodes (melting, precipitation,
Mounting) its mass m and the intensity of the current applied is I (A), and g of the passage of the current is t (s).

The first law in its mathematical form :

$$m \propto Q \Rightarrow m \propto I.t$$

$$m = K.I.t$$

In terms of w K: Constant proportionality, called electrochemical equivalent

equivalents) . Its value depends on the substance on which it is t.

It is possible to define the electrochemical equivalent of K Riadiya:

$$K = \frac{m}{I.\,t}$$

$$K = \frac{m}{Q} = g/C$$

From the mathematical relationship m/Q) = (K) it is possible to define the electrochemical equivalent as:

The amount of substance (in grams or kellograms) that occursin the form of oxidation or sister of the g)

The result of the passage of a quantity of electricity amounting to one coulomb .

Calculation of electrochemical equivalent :

It is calculated from the following non-data:

$$K = \frac{Mw}{Z\,F} = \frac{Ew}{F}$$

Or

$$K = \frac{Aw}{Z\,F} = \frac{Ew}{F}$$

H (Mw) expresses the Ogngge . when the NAT C
G G G
Y is like
(H_2 , Cl_2 ....) , Binma (Aw) expresses the atomic aloe g n whenthe nat c is a metal such as
,... ...) . (Ag, Cu

The (Ew) expresses the equivalent of the G n and is the division of the Gn G Y or the Lo G N
Atoms on (Z) are the number of mobile electrons in the Mo G
One reaction.

Definition of Alfaradai

It is the amount of electricity that has been charged equivalent to the charge of one mole of electrons and has the capacity
On the deposition of a single grammatical equivalent of any element.
Or Faradai is the amount of electricity that must be taken by a cell in order to be one mola
From electrons.
1 Faraday = Charge of Mole of Electrons
It is suggested that the charge of one electron is equal to = 1.60198 x 10 -19 Coulomb.
Thus the shipment of one Faraday is equal to :

$$1\text{Faraday} = 1.60198 \times 10^{-19} \times 6.023 \times 10^{23} = 96487 \text{ Coulomb}$$

For approximation , we will use Faraday's value of 96500 C to facilitate calculations . And the number
For Alfaradi (96487 C) found by experiment before being proven by calculations.

Definition of Coulomb

It is the amount of Hannah St. that moves after any given point of the circle when a current passes through it .
The amount of 1 amp e (1 A) for 1 second (1S)

1 second × 1 ampere = 1 coulomb

$$1 \text{ C} = 1 \text{ A.S}$$

Calculation of the amount of electricity Q:

(1) The amount of electricity is calculated from the world:

$$Q = I\ .\ t$$

H w I : The intensity of the current in the ampere unit .(A)
T : The g of the second unit . S)The unit of quantity of electricity (Q) is (A.S.) orCoulomb (C) (2) To convert the quantity of electricity to Faraday,we follow the following :

$$F = \frac{Q}{96500}$$

$$m = \frac{Aw\ .\ I.\ t}{Z\ .\ F}$$: Laws Derived From Faraday's First Law

(1) The value I.t/F expresses the number of Faradai(F) where :

$$F = \frac{I\ .\ t}{96500}$$

By twisting it in the equation $m = \frac{Aw\ .\ I.\ t}{Z\ .\ F}$

$$m = \frac{Aw\ .\ F}{Z}$$

And we have already explained in the chapter on ways to express concentration that the number of moles n:

$$n = \frac{m}{Aw}$$

$$m = n\ .\ Aw$$

By twisting $m = n\ .\ Aw$ in the equation $m = \frac{Aw\ .\ F}{Z}$ we get :

$$n\ .\ Aw = \frac{Aw\ .\ F}{Z}$$

By dividing the two ends by AW we get :

$$n = \frac{F}{Z}$$

H F: The amount of electricity in Faradai.

When the quantity of electricity is converted by the coulomb in the in-n $n = \frac{F}{Z}$ no time to:

$$n = \frac{F}{Z}$$

$$n = \frac{Q}{Z \times 96500}$$

$$n = \frac{I \times t}{Z \times 96500}$$

Faraday's Second Law

It reads:

When the same amount of electricity passes, in two electric analyzes connected to
Respectively, the quantities of substances that are exposed to the electrodes (oxidation or sister of the g)
i is proportional to the or g it is the equivalent. "
Where is that one passage Faraday (96500 C) in the cell of electrical analysis y led to
Depositation (or escalation) of one grammatical equivalent of the substance on which it occurs (oxidation or
Sister G L) at the pole .

The two masses of the two substances that are t and are or g are the masses of the two substances that are t and were or g they are
Equivalence (Ew_{1}, Ew_{2}), FN Law II enables Sia Gh Riyadiya:

$$m_1 \; \alpha \; Ew_1 \Rightarrow m_1 = K \,.\, Ew_1$$

$$m_2 \; \alpha \; Ew_2 \Rightarrow m_2 = K \,.\, Ew_2$$

$$\frac{m_1}{m_2} = \frac{\cancel{K} \,.\, Ew_1}{\cancel{K} \,.\, Ew_2}$$

$$\frac{m_1}{m_2} = \frac{Ew_1}{Ew_2}$$

And the last formulation :

$$\frac{m_1}{m_2} = \frac{Ew_1}{Ew_2}$$

It expresses the second law of Faraday .

And to calculate the equivalent of any metal deposited on the pole, we divide the atomic G by

The number of mobile electrons in the reaction.

(Potential differences)

H and P Raq the side D B Yen dotted Yen from D s you have a Moss to protect for TR Thap T
s dora ambi r and one d in it a s perish   s s   dora and one d and iq   s with beans t l this
We conclude the following relationships to calculate the voltage difference:

$E=w/Q$

$E=p/I$

$P=w/t$

Special relations of the laws of Verdai

(1) Electric charge in Coulomb:

$Q=I\times t$

(2) Electric charge (in electron moles)

$Q=I\times t/96500$

(3) To find the deposited or liberated mass by the following relationships:

a) $m=M/IZI.F\ .\ I.t$

b) $m=n\times M$

(4 Lig Ed Hajj M G Z Muttah Rar F Z Z Roof Measurement Yeh

We use the following relationship :

$$PV = nRT$$

Eg   ed Hajj M F Y Z ROOF experimental H J B N NGD D ROOF
Standard then we switch to experimental conditions:
Use of the Uniform Law on Gases

$P1V1/T1=P2V2/T2$

5. Finding the number of molecules or atoms we use the following relationship

n×NA(6.02 10 23) = NO(Molecules or atomic)

6) To find the number of electrons passing through the solution

NA (6.02 10 23) × n = No(Electro passing)

(7) To find an electric charge, the following relationships can be used:

Q= m/M * Z

Q= Vs.T.P/22.4 * Z

b)Q = NO(Molecules or atomic)/ NA

c) $Q=Z(n_1- n_2)$

n_1 = mol before analysis (total)

=n2 moles after analysis (consumer)

Note: A relationship can be found between the electric charge (mol.e) Q with

The number of malls of sedimentary metal, for example When reducing copper

$$Cu^{+2} \ +2e \longrightarrow Cu$$

The relationship between the electric charge (mol.e) and the volume of the gas can be found

The Liberator at S.T.P

Duty: To free the hydrogen gas, a cathode must be taken and the rest must be liberated.

Gases must be exhibited by anode?

Duty: the anode is eaten and the weight decreases and the cathode is getting thicker?

$2H+2e \rightarrow H_2$ For example when reducing hydrogen

Fradi (F)

Represents the amount of electrical charge needed to form a single Grammy McCafee

From Article IN :

$F= Q / 96500$

The Fradi constant (F) is as much as the charge it carries.

The number of avcadro electrons is equal to:

$F=NA \times e = 6.02 \times 10 \quad \times 1.6 \times 10^{-}$

$=96487$ .... $96500\ C.MoL^{-}\ 1$ -

We benefit from the many laws of Faradi Ragh and the corresponding effect of the results

The process for the quantities of substances formed and deposited at the electrodes

Electrolysis of electrolytic analyzers but does not give information

About the mechanism of speed of interactions.

(1) example

calculate the weight electrochemical equivalent of each of the hydrogens and silver.
if you know atomic mass(Ag = 108, H = 1)

Solution

Aw

$$2H^{+} + 2\bar{e} \longrightarrow H_2(g)$$

$$K_{H_2} = \frac{2 \times 1}{2 \times 96500} = 1.036 \times 10^{-5} g/C = 1.04 \text{ x } 10^{-8} \text{ Kg/C}$$

$$Ag^{+}(aq) + \bar{e} \longrightarrow Ag$$

$$K_{Ag} = \frac{108}{1 \times 96500} = 1.119 \times 10^{-3} \text{ g/C} = 1.12 \times 10^{-6} \text{ Kg/C}$$

And in compensation for the value of $K = \frac{}{Z\,F}$ In the first law $m = K\,.\,I\,.\,t$ We get:

$$m = K\,.\,I\,.\,t$$

$$m = \frac{Aw}{Z\,F}\,.\,I\,.\,t$$

or $m = \frac{Aw\,.\,I\,.\,t}{Z \times 96500}$ (where Aw for deposited atoms : Na, K, Cr, Cu, Ag)

$m = \frac{Mw\,.\,I\,.\,t}{Z \times 96500}$ (where Mw for released molecules as : H_2,Cl_2)

Example (2)

If an electrostatic current is passed (10.4 A) for (23 Min) in a solution of potassium iodide

KI, calculate the mass of materials that accumulate at the poles.

if you know atomic masses : (I=127 = K =39.1)

Solution

The equations for the iodine and potassium precipitation reactions are:

$$K^+ + \bar{e} \xrightleftharpoons{\text{reduction}} K$$

$$2I^- \xrightleftharpoons{\text{oxidation}} I_2 + 2\bar{e}$$

By applying Faraday's first law, the masses of precipitated potassium and iodine can be calculated:

$$m_{I_2} = \frac{Mw \cdot I \cdot t}{Z \cdot F}$$

$$m_{I_2} = \frac{(2 \times 127) \times (10.4) \times (23 \times 60)}{2 \times 96500}$$

$$m_{I_2} = 18.89 \text{ g}$$

$$m_K = \frac{Aw \cdot I \cdot t}{Z \cdot F}$$

$$m_K = \frac{39.1 \times 10.4 \times 23 \times 60}{1 \times 96500}$$

$$m_K = 5.8 \text{ g}$$

Example (3)

Calculate the g of the time required to deposit (2.16 g) from a silver when passing an electric current in

Silver Nitrate solution of intensity (32 A) if you now that the atomic mass of the Ag is equal to (108)

Solution

$$Ag^{+}(aq) + \bar{e} \longrightarrow Ag(s)$$

$$m_{Ag} = \frac{Aw.\ I.\ t}{Z.\ F}$$

$$t = \frac{m_{Ag}.Z.\ F}{Aw\ .\ I}$$

$$t = \frac{2.16 \times 1 \times 96500}{108 \times 32} = 60.31\ S$$

Example (4)

When an electric current passes over two connected cells in a series (the intensity of the passing current One), one of which contains a solution of $CuSO_4$ and the other contains a solution of $AgNO_3$, A of one deposited of (2 g) for Ag

calculate:

a) precipitated copper wieght

b) The intensity of the current passing through the deposition of (2 g) of Ag in time of one hours

if you know atomic (Ag= 108 : Cu= 63.5)

Solution

a) By applying the second law of Faraday :

$$\frac{m_{Ag}}{m_{Cu}} = \frac{Ew_{Ag}}{Ew_{Cu}}$$

$$\frac{2\ g}{m_{Cu}} = \frac{(108/1)}{(63.5/2)}$$

$$\frac{2\ g}{m_{Cu}} = \frac{108}{31.75}$$

$$m_{Cu} = \frac{2 \times 31.75}{108}$$

$$m_{Cu} = \frac{63.5}{108}$$

$$m_{Cu} = 0.59\ g$$

By applying the law of Faraday I:

$$m_{Ag} = \frac{Aw_{Ag} . I . t}{Z . F}$$

$$2 = \frac{108 \times I \times 3600\ S}{1 \times 96500}$$

$$I = \frac{2 x 1 \times 96500}{108 \times 3600}$$

$$I = 0.5A$$

Example (5)

what is the volume of hydrogen a for d (25 º C) and pressure (740 mmHg) the
It is generated during the electrolysis of water with a current of intensity (10 A) g in time of (0.5 h)

Solution

By applying the law of Faraday Nojd and the liberal hidrogen:

$$m = \frac{Mw . I . t}{z . F}$$

$$m = \frac{2 \times 10 \times 0.5 \times 60 \times 60}{2 \times 96500}$$

$$m = 0.186\ g$$

By applying the general law of the ideal GZAT, we find the size of the GZAG as follows:

$$P\,V = n\,R\,T$$

$$\frac{740}{760} \times V = \frac{0.186}{2} \times 0.0821 \times 298$$

$$V = \frac{\frac{0.186}{2} \times 0.0821 \times 298}{\left(\frac{740}{760}\right)}$$

$$V = 2.34\ L$$

$$V = 2340$$

Another way ~~to~~ solve

And it is possible to solve the pain of the mother by the way of brother R i ~~and~~ M N I know that the pilgrimage of the pain and the G a G from D Z Roof Measurement Y (760 mmHg, 273 K) J Sawy (22400 cm 3) Walt to FN Hajj M

Mole of GA g Hydrogen at (740 mmHg, 298 K):

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{760 \times 22400}{273} = \frac{740 \times V_2}{298}$$

$$V_2 = \frac{760 \times 22400 \times 298}{273 \times 740}$$

$$V_2 = 25112.13\ cm^3$$

And this is it and Hajj m m and one d m n g a g h e Drogin from D D Z Roof (740 mmHg, 298 K) Thus the volume (0.186 mol) of the GZA :

$$1 \text{ mol of } H_2 \text{ (at 740 mmHg, 298 K)} \longrightarrow 25112.13 \text{ cm}^3$$

$$\frac{0.186}{2} \text{ mol of } H_2 \text{ (at 740 mmHg, 298 K)} \longrightarrow x$$

$$x = \left(25112.13 \text{ cm}^3/\text{mol}\right) \times \left(\frac{0.186 \text{ mol}}{2}\right)$$

$$x = 2335.43 \text{ cm}^3$$

. And it's close to the previous result.