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QUANTITY IN PHYSICS ON THE LAWS OF ELECTROLYSIS PROBLEM SOLUTION TECHNOLOGY

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ABSTARCT

This paper describes the technology of solving quantitative problems in physics on the laws of electrolysis. Faraday's technology for selecting, constructing, and solving interdisciplinary problems on the laws of electrolysis is described in a consistent, logical manner.

KEYWORDS: *Electrolysis, Electrolyte, Electrode, Anode, Cathode, Substance, Mass, Charge, Time, Solution, Conductor, Contact.*

INTRODUCTION

1- question. Electrochemical equivalent of chromium $0{,}18\cdot10^{-6}$ kg / Kl, if 1 Kl of electric charge passes through the electrolyte, how much chromium is released during electrolysis? What if a charge of 20 Kl and 0.2 Kl is passed?

Given:	Formula:	Solution:
$k = 1{,}8\cdot10^{-6}$ kg/ Kl	$m = kq$	$m = 1{,}8\cdot10^{-7}$ kg/Kl ·1 Kl $=1{,}8\cdot10^{-7}$ kg.
$q = 1$ Kl	$m_1 = kq_1$	$m_1 = 1{,}8\cdot10^{-7}$ kg/Kl ·20 Kl $= 3{,}6\cdot10^{-6}$ kg
$q_1 = 20$ Kl	$m_2 = kq_2$	$m_1 = 1{,}8\cdot10^{-7}$ kg/Kl ·0,2 Kl $= 3{,}6\cdot10^{-8}$ kg
$q_2 = 0{,}2$ Kl		
$m = ?$		
$m_1 = ?$		
$m_2 = ?$		

Answers: $m = 1{,}8\cdot10^{-7}$ kg; $m_1 = 3{,}6\cdot10^{-6}$ kg; $m = 3{,}6\cdot10^{-8}$ kg.

2- question. Water is obtained from oxygen and hydrogen in the laboratory (by electrolysis, of course). How much oxygen is released at the anode and how much hydrogen is released at the cathode when a current of 1.2 A passes through the circuit in 30 min?

Given:

I = 1,2 A
t = 1,8 ·10^3 c

$m_{0_2} = ?$
$m_{H_2} = ?$

Formula:

$$m_{H_2} = k_{H_2} \cdot It$$
$$m_{0_2} = k_{0_2} \cdot It$$
$$k_{0_2} = 8{,}3 \cdot 10^{-8} \frac{\text{kg}}{\text{Kl}}$$
$$k_{H_2} = 10^{-8} \frac{\text{kg}}{\text{Kl}}$$

Solution:

$$m_{H_2} = 10^{-8} \frac{\text{kg}}{\text{Kl}} \cdot 1{,}2\ A \cdot 1{,}8 \cdot 10^3\ c = 2{,}16 \cdot 10^{-5}\ \text{kg}.$$
$$m_{0_2} = 8{,}3 \cdot 10^{-8} \frac{\text{kg}}{\text{Kl}} \cdot 1{,}2\ A \cdot 1{,}8 \cdot 10^3\ c \approx 1{,}8 \cdot 10^{-4}\ \text{kg}.$$

Question. $m_{H_2} = 2{,}16 \cdot 10^{-5}$ kg;

$m_{.0_2} \approx 1{,}8 \cdot 10^{-4}$ kg.

3- question. At what layer thickness of metal parts with a surface area of 120 cm2 is nickel plated with a current of 0.3 A for 5 hours? The valence of nickel is 2, the molar mass 58,7 ·10^{-3} kg / mol , density 9 ·10^3 kg /m^3 equal.

Given:
t = 1,8 · 10^4 c
ρ = 9 · 10^3 kg /m^3
S = 1,2 ·10^{-2} m^2

d = ?
m = ?

Solution:
The mass of nickel that separates on the surface of the product $m = \frac{Aq}{nF}$ on the other hand, m= ρSd.

So, $d = \frac{m}{\rho S}$ will be. If we find the mass and layer thickness:

$$m = \frac{58{,}7 \cdot 10^{-3} \frac{\text{kg}}{\text{mol}} \cdot 1{,}8 \cdot 10^4\ c \cdot 0{,}3\ A}{2 \cdot 9{,}65 \cdot 10^4\ \text{Kl/mol}} = 1{,}65 \quad 10^{-3}\,\text{kg}.$$

$$d = \frac{1{,}65 \cdot 10^{-3}\,\text{kg}}{9 \cdot 10^3\ \text{kg/m}^3\, 1{,}2 \cdot 10^{-2}\ \text{m}^2} = 1{,}53 \cdot 10^{-5}\,\text{m}.$$

Answers: d = 1,53 ·10^{-5} m; m = 1,65·10^{-3} kg.

4 - question. When oxidized (fermented) water is electrolyzed at a temperature of 270 C and normal atmospheric pressure, what is the minimum amount of electricity that a battery should have in order to release 5 liters of oxygen?

Given:
T = 300 K
V = 5·10^{-3} m^3
ρ_o = 10^3 кг/m^3

Solution:
We find the amount of electricity required for electrolysis from this relationship: m = kq; $q = \frac{\text{m}}{\text{k}}$.

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$T_o = 273$ K

$k = 8{,}29 \cdot 10^{-8} \dfrac{\text{kg}}{\text{Kl}}$

q = ?

The mass of oxygen released $m = \rho_o V_o$ formula, V_o the volume is the Gay-Lussac law $V_o = \dfrac{VT_o}{T}$ can be found from. This, $q = \dfrac{VT_o\rho_o}{Tk}$ (1) will be

we perform the calculation by placing the numerical values of the quantities in formula (1).

$$q = \frac{5 \cdot 10^{-3}\ \text{m}^3 \cdot 273\ \text{K} \cdot 1{,}43\ \text{kg/m}^3}{300\ \text{K} \cdot 8{,}29 \cdot 10^{-8}\ \text{kg/Kl}} \approx 7{,}8 \cdot 10^4\ \text{Kl}.$$

In fact, the capacity of a battery is measured in Ampere · hours, but we have expressed its unit in Coulomb, considering SI.

Answer: Battery charge $7{,}8 \cdot 10^{-4}$ Kl should not be less than.

5- question. Gelvano-plate is used in the manufacture of matrices of gramplates. Initially wax form (shape) 0,8 A/dm^2 coated with copper for 30 min at current density. In this case, the current separation is 90%. The next coating process 5A/dm^2 at a current density for 20 hours. In this case, the current separation is 95%. The surface area of a gramophone record 3 dm^2 if so, how much copper will be consumed on average to obtain a single plate plate matrix?

Given:

$I_1 = 80$ A/m^2

$I_2 = 5 \cdot 10^2$ A/m^2

$t_1 = 1{,}8 \cdot 10^3$ c

$t_2 = 7{,}2 \cdot 10^4$ c

$\eta_1 = 90\% = 0{,}9$

$\eta_2 = 95\% = 0{,}95$

$S = 3 \cdot 10^{-2}$ m^2

$k = 3{,}3 \cdot 10^{-7}$ kg/Kl

m = ?

Solution:

Indicates how much of the mass of the substance released during electrolysis is the pre-calculated (by current) mass, $\eta = \dfrac{m}{m_{account.}}$

in this $m_{account}$ Determined from Faraday's 1st law. The mass of copper separated in the primary coating

$\eta_1 = \dfrac{m_1}{m_{account.}}$ in this

Can be determined from the relationship. Given that I = iS, we obtain:

$m = \eta_1 k J_1 S t_1$

In the same way we create the expression m_2:

$m_2 = \eta_2 m_{2\ \text{хисоб.}}$, $m_2 = \eta_2 k J_2 S t_2$

The total amount of copper extracted

$m = m_1 + m_2 = kS(\eta_1 J_1 t_1 + \eta_2 J_2 t_2)$

will be. We calculate this expression by substituting the numerical values of the quantities.

$m = 3{,}3 \cdot 10^{-7}$ kg/Kl $\cdot\ 3 \cdot 10^{-2}$ m^2. (0,9 ·80 A/м^2 · 1,8 10^3 c + 0,95 ·

500 A/m^2 · 72 10^3 c) ≈ 0,34 kg.

Answer: It takes about 0.34 kg of copper to make one matrix.

6- question. The surface of metal objects is electrolytically coated with 20 μm thick silver. A current density $2,5\cdot10^{-3}$ A/cm^2 If so, how long will the electrolysis take?

Given:
$h = 20$ mkm $= 2\cdot10^{-5}$ м
$J = 2,5\cdot10^{-3}$ A/cm^2 = 25 A/m^2
$к = 1,118\cdot10^{-6}$ kg/Kl
$\rho = 10,5\cdot10^{3}$ Kl/м^3
$\mu = 108\cdot10^{-3}$ kg/mol
$F = 9,65\cdot10^{4}$ Kl/ mol
$n = 1$
$t = ?$

Solution:
1-method. We solve the problem using Faraday's law 1 for electrolysis. $m = kIt \Rightarrow t = \frac{m}{kI}$ (1).
We find the mass and current using the following formulas:
$m = \rho S h$ (2); $I = jS$ (3).
(1) to (2) and (3) of take away

$$t = \frac{\rho h}{nJ}$$ (4) is formed.

Now we calculate by substituting the numerical values instead of the quantities to the right of formula (4).

$$t = \frac{10,5\cdot10^{3}\ \text{кг/м}^{3}\cdot 2\cdot10^{-5}\ \text{м}}{1,118\cdot10^{-6}\ \text{кг/Кл}\cdot\text{А/м}^{2}} = 7,5\cdot10^{3}\ c\,.$$

2-method. If the numerical value of the electrochemical equivalence is not given, then the problem can be solved on the basis of Faraday's unified law. $m = \frac{A}{F}\frac{\mu}{n}It$, from here $t = \frac{mF\cdot n}{\mu I}$ (1) formula is formed. Mass and current strength using the above formulas, that is 1-method: $m = \rho V = \rho Sh$; J = IS in that case $t = \frac{\rho hFn}{AJ}$ (2) derived from the formula.

Now we calculate by substituting the numerical values instead of the quantities to the right of formula (2).

$$t = \frac{10,5\cdot10^{3}\text{kg/m}^{3}\cdot 2\cdot10^{-5}\ \text{m}\cdot 9,65\cdot10^{4}\ \text{Kl/mol}\ \cdot 1}{108\cdot10^{-3}\ \text{kl/mol}\cdot 25\ \text{A/m}^{2}} = 7,5\cdot10^{3}\ c.$$

Answer: For silver $7,5\cdot10^{3}$ c or about 2.1 hours.

7- question. From fermented water through an electrolytic bath (during electrolysis) 27 ^{0}C temperature and 10^5 Pa at pressure 1 dm^3 How to charge to get gas?

Given:
$p = 10^5$ Pa
$V = 1$ dm^3 = 10^{-3} m^3
$F = 9,65\cdot10^{4}$ Kl/mol
$T = 300$ K
$q = ?$

Solution:
First, we determine the amount of gas (in molars):
$\nu = pV/RT$, бу ерда R = 8,31 J/ (mol·K) in the electrolysis of water, hydrogen atoms are released twice as much as oxygen atoms. The amount of hydrogen $V_1 = 2\,V/3 = \frac{2\rho V}{3RT}$.

Given that a gaseous hydrogen molecule is made up of two atoms, we create the charge we are looking for according to Faraday's laws.

$$q = F \cdot 2\,V_1 = \frac{4FpV}{3RT}$$

Now we calculate the numerical values instead of the quantities involved in the equation.

$$q = \frac{4 \cdot 9{,}65 \cdot 10^4 \text{ Kl/mol } \cdot 10^5 \text{ Pa} \cdot 10^{-3} \text{ m}^3}{3 \cdot 8{,}31 \cdot 10^3 \text{ J/(mol K)} \cdot 0{,}3 \text{ K}} = 5{,}2 \cdot 10^3 \text{ Kl.}$$

Answer: q = $5{,}2 \cdot 10^{-3}$ Kl.

It is advisable to address the above issues in order to determine the extent to which students have mastered the theoretical knowledge, practical skills and competencies acquired in the subjects of physics and chemistry.

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