

IMPROVING THE METHODOLOGY OF TEACHING THE TOPIC "ELECTROLYSIS" IN THE SCHOOL CHEMISTRY COURSE BASED ON A DIFFERENTIAL APPROACH

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Abstract. *The topic of electrolysis is somewhat simplified and not fully explained in school textbooks. Therefore, this topic has been enriched with additional resources and interesting descriptions on the differential approach based on interdisciplinarity. General concepts of electrolysis, rules according to it, laws of electrolysis, Faraday constant units, electrolysis applications, electrolysis devices, various electrolysis processes, fields of application in the economy and agriculture were studied on the basis of differentiation.*

Keywords: *electrolysis, Faraday's laws, anode, cathode, current source, proportionality coefficient, amount of substance, equivalent, coulomb, constant, electrolyzers, electrolytic bath, amperes, radio engineering, electronics, polygraphy, solubility.*

Introduction. In school textbooks, the topic of electrolysis is explained as follows: electrolysis refers to oxidation-reduction processes that occur at electrodes when a constant electric current passes through a heated and liquefied electrolyte or its solution in water. The essence of electrolysis is to carry out a chemical reaction at the expense of electrical energy. When an electric current is applied, the phenomenon of electron acceptance or electron donation of ions constitutes the primary process. As a result of this process, the primary products of electrolysis are often formed. Products of electrolysis can be released in pure form or undergo a chemical reaction with the solvent. In the second case, secondary products of electrolysis are formed. When heated liquefied electrolytes are electrolyzed, only primary products are released. In solutions of electrolytes in water, electrolysis is more complicated, as secondary processes take place in it. In general, the progress of the electrolysis process and what products are formed at the end of electrolysis depend on the primary products, the nature of the solvent, the material of the electrodes, the current density in the electrodes, etc. The cathode, that is, the electrode connected to the negative pole of the DC source, acts as a reducing agent, while the anode (that is, the electrode connected to the positive pole of the source) acts as an oxidizing agent. There are connections expressed by mathematical equations between the masses of the substances released at the electrodes, the current strength and the duration of electrolysis. These sources, in turn, refer to Faraday's laws.

The quantitative significance of the phenomenon of electrolysis was studied by M. Faraday in the 1930s. He created the laws of electrolysis based on his experiments.

1. The weight of the substance released during electrolysis is proportional to the amount of electricity passed through the solution and does not depend on any other factors.

$$m=k*Q [1]$$

The here; amount of m-substance, k-proportionality coefficient (it is also called the electrochemical equivalent of the substance and it shows the amount of substance released from

the electrolyte when one ampere of current or one coulomb of electricity is absorbed per second). The amount of electricity lost from the Q-electrolyte (in coulombs).

2. An equal amount of electricity separates an equivalent amount of substances from different chemical compounds during electrolysis. For example: when the same amount of electric current is passed through a solution of HCl, AgNO₃, CuSO₄, FeCl₃, SnCl₄, an equivalent amount of H₂, Ag, Cu, Fe, Sn is released at the cathode. During electrolysis, 96,500 coulombs of electric current must pass through the electrodes to separate one gram equivalent of substance.

$$K = \frac{1}{96500} * E \quad [2]$$

The mathematical expression of the first and second laws is written as follows:

$$m = \frac{EQ}{96500}: \quad [3] \quad \text{from this } m = \frac{EIt}{96500} \quad [4] \quad \text{originates.}$$

Here, m is the amount of reduced or oxidized substance, E is the equivalent of substance, Q is the amount of electricity. If I*t is burned instead of Q, [4] is formed. I-current strength, t-current transit time (in seconds). Knowing Faraday's laws, the following can be calculated:

- a) the amount of substance released by the amount of electricity;
- b) current strength depending on the amount of released substance and the time of passing the current through the electrolyte.

Research materials and methodology. On the basis of these sources, it is possible to strengthen the improvement of the methodology of teaching the topic "Electrolysis" based on a differential approach as follows. When the current passes through the electrolytes, we carry out the process of electrolysis. An electrolyte is an ionic substance that dissociates into its component ions when placed in a solvent. The introduction of positive and negative ions from the dissociation of electrolytes creates a new solution capable of conducting electricity. How well this new solution conducts electricity depends directly on the strength of the electrolyte used. Strong electrolytes are those that dissociate nearly 100% in solution, while weak electrolytes are those that dissociate less (<10%). When used in an industrial or experimental setting, electrolysis often involves the extraction of metals by deposition for processes such as electroplating or refining. Faraday's laws of electrolysis can be used to help relate mass and charge so that electrolysis can be used as a more efficient means. Faraday's first and second laws of electrolysis state that:

$$m * Q: \quad m * E$$

where m is the mass, Q is the total charge, E is the equivalent weight of the electrolyte. Equivalent weight is expressed as: $E = \text{Atomic weight}$.

If we want to write the first law as an equality, we require a proportionality constant. Through his experiments, Faraday found that 98,465 coulombs (one Faraday charge) could discharge one gram of material from the electrodes. Using this, Faraday was able to determine the proportionality constant Z:

$$Z=96,485$$

Rewriting the first law using this constant gives the equation, $m=ZQ$. Here, the Faraday constant (F) is equal to 96,485 coulombs per mole (C mol).

Faraday constant units. In addition to Faraday's constant (F), there are two other constants related to the electrolysis process. These two constants are Avogadro's constant (L) and the value of the standard electron charge (ϵ).

- Faraday's constant, F: 96,485Cmol
- Avogadro's constant, L: $6,02 \times 10^{23}$

- Electronic charge, e : $1,6023 \times 10^{-19} \text{C}$

To show why the units of Faraday's constant are Cmol, let's see how it is calculated. Faraday's constant indicates the amount of charge that one mole of electrons can carry. If we know that the charge of one electron is $e=1.6023 \times 10^{-19} \text{C}$ and there are 6.02×10^{23} electrons per mole, then the Faraday constant is equal to,

$$F=e \cdot L=1,6023 \times 10^{-19} \text{C} \cdot 6,02 \times 10^{23} \text{mol}^{-1} \approx 96,485 \text{Cmol}$$

Our final units for Faraday's constant are Cmol because the first term brings units of coulombs to the numerator and the second term brings units of moles to the denominator. Faraday's Law of Electrolysis: Faraday's first law of electrolysis relates the mass of a substance released (or deposited) at an electrode to the applied electric charge (Q). The proportionality constant Z can be used to rewrite the first law as:

$$m=ZQ=E96,485Q$$

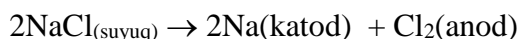
where m is the mass of the substance, E is the equivalent weight of the substance, Q is the total charge. We can also rewrite Q in terms of the current used:

$$Q=I \cdot t:$$

where current (I) is measured in amperes and time is measured in seconds.

Application of electrolysis.

1. Using electrolysis, alkali and alkaline earth metals and some active metals are separated from their compounds. For example,



2. Using electrolysis, gases, some acids and other substances can be separated. For example,



3. Electrolysis is used to cover the surface of metals with other metals.

4. Electrolysis is extremely important in industry. Many areas of the current chemical industry cannot be imagined without it.

Discussion. Electrolysis is widely used in various industries. In the chemical industry, it is used in the extraction of chlorine and alkali, in the production of chlorate, perchlorate, persulphuric acid, potassium permanganate, pure hydrogen, fluorine, and other valuable products, in the refining of metals in non-ferrous metallurgy. The compounds of various metals are heated and liquefied, and those metals are separated using electrolysis. In mechanical engineering, radio engineering, electronics, and printing industries, electrolysis is used to cover the surface of various objects with metals, etc.

The electrolysis process is carried out in special devices - electrolyzers or electrolytic baths. The processes that take place in the anode depend on both the electrolyte and the material from which the anode is made. Anodes are of two types:

1. Soluble anode.
2. Insoluble anode.

Pure metals are obtained using a soluble anode electrode. Such an electrolysis process should be carried out in a solution of the metal salt being purified. In industry, copper, zinc, cadmium, nickel, cobalt, manganese and other metals are obtained by electrolysis of salt solutions. Using this method, one metal is coated with another metal. This method is called galvanostegy.

Soluble anodes are electrodes that pass into the solution in the form of ions during electrolysis. For example: if a constant current is passed through CuCl_2 and a copper plate is taken as an anode, copper ions are returned at the cathode, and copper is oxidized at the anode.

Because copper atoms donate electrons more easily than copper ions. Therefore, the concentration of copper ions in the solution does not change.

Inert carbon (C) and passive metals (Au, Pt) can be used as insoluble anodes. During electrolysis with such electrodes, the oxidation process at the anode occurs not at the expense of the electrode, but at the expense of insoluble anions or water molecules. For example: at the anode, only oxygen-free acid residues: chlorine, bromine, iodine, fluorine, sulfur, etc. are discharged from electrolyte anions.

Ions that can be oxidized at the anode during electrolysis are oxygen acid residues (NO_3^- , NO_2^- , SO_3^{2-} , SO_4^{2-} , PO_4^{3-} , CO_3^{2-}) and H_2O molecules. Oxygenic acid residues from these ions are not discharged at the anode, instead, water molecules are oxidized. Deoxygenated acid ions are easily oxidized and released freely.

When potassium sulfate solution is electrolyzed, hydrogen is released at the cathode and oxygen at the anode. The dissociation scheme is as follows:

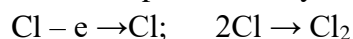


written in order. The electrolysis scheme is as follows:

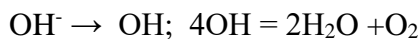
At the cathode $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2 \uparrow$ the environment of the reduction process is alkaline. At the anode $4\text{OH}^- - 4\text{e}^- = \text{O}_2 + 2\text{H}_2\text{O}$ the oxidation process is acidic.

As it can be seen from the given examples, the ions of alkali metals are not returned to the cathode, and hydrogen ions of water are returned to them instead. If there is an oxygenated acid in the anode, then the water in the anode electrode is also oxidized by giving electrons.

Depending on the nature of electrolytes and electrodes, electrolysis is different. Water solutions of electrolytes contain H^+ , OH^- in addition to the electrolyte solution. When the solution is connected to a current source, electrolyte ions and water ions flow to the electrodes. The cation of the electrolyte and the hydrogen anion of water go to the cathode. What ions are rejected at the cathode, what ions are oxidized at the anode. In this case, it is necessary to know which of the cations or H^+ ions of the electrolyte, anions or hydroxide ions of the electrolyte are relatively active. The activity of cations can be determined based on the series of electrochemical voltages, which basically corresponds to the series of displacements of metals proposed by the Russian scientist N.N. Beketov. If the electrolyte is in front of hydrogen, it is difficult to attach electrons, so it is not neutralized at the cathode, hydrogen ions in water are neutralized - oxidized, and hydrogen atoms are separated in front of the cathode, forming molecules. Metal cations before hydrogen in the electrochemical voltage series are not reduced in electrolysis, metal cations in water solution of metal electrolytes after aluminum are neutralized in front of the cathode, because these metals are not strongly reducing. It is obtained by electrolysis of diluted compounds up to aluminum. Copper, silver, gold cations in the voltage range are easily subjected to electrolysis, they are immediately neutralized at the cathode. Non-oxygen anions are more easily oxidized than oxygen anions. If the electrolyte anion is oxygen-free (F^- , Cl^- , Br^- , I^- , S^{2-} , CN^-) gives its electrons to the anode and separates freely.

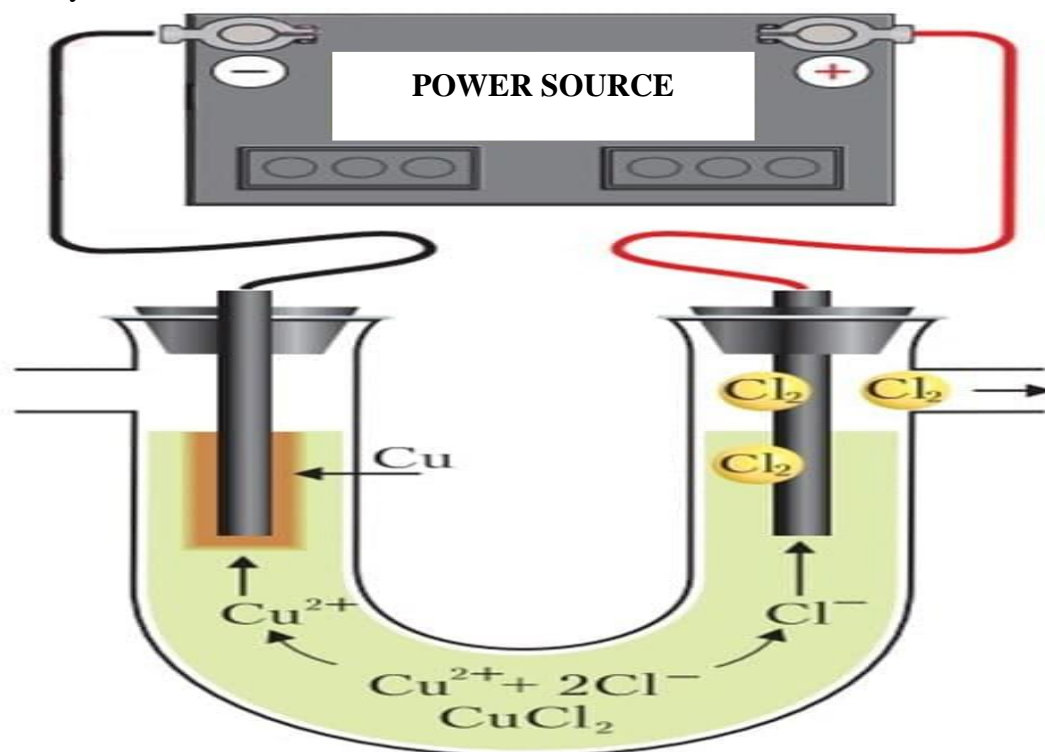


If the anions are oxygenated, the OH^- ions of water give up their electrons more easily than they do:



Therefore, oxygen is released in front of the cathode. Based on the above-mentioned ideas and instructions, we will get acquainted with the process of electrolysis of copper chloride

solution. What material the anode is made of is also important in copper chloride electrolysis. Electrodes are often made of inert materials such as carbon graphite and passive metals - platinum, gold. If the electrolyte consists of metals such as copper, nickel, the anode itself is oxidized, the anode atoms turn into ions and pass into the solution, from the solution to the cathode, they are neutralized.

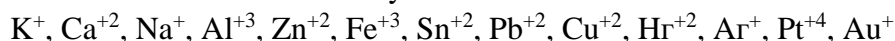


Electrolysis of copper chloride solution.

Neutralization of ions during electrolysis is called the first reaction of electrolysis. Some electrolytes are neutralized and oxidized in electrolysis, and the reduced substances react with each other or with water. For example, when an electric current is passed through a solution of copper chloride, the copper and chlorine ions in the solution are directed towards the corresponding electrodes, and the following process occurs: at the cathode $\text{Cu}^{2+} + 2\text{e} = \text{Cu}$; in the anode $2\text{Cl}^- - 2\text{e} = \text{Cl}_2$. When an electric current passes through a solution of salts of metals with an electric potential of less than -0.41 V , water molecules, not metal ions, should return to the cathode. When a solution of table salt in water is electrolyzed, the following changes occur. At the cathode Na^+ ; In the anode 2Cl^-



There are 2 types of anodes: soluble and non-fusible. Soluble anodes are destroyed during electrolysis. Such anodes are used in the electrolysis industry to obtain very pure substances, to coat one metal with another metal. When a solution of oxygen salts in water is electrolyzed, water molecules are oxidized at the anode to form oxygen gas. If a solution of active metal and oxygen acid salts in water is electrolyzed, water is reduced at the cathode and oxidized at the anode, resulting in the formation of hydrogen at the cathode and oxygen at the anode. Currently, liquefied salts of many metals are obtained by electrolysis: Al, Mg, Ca, Na; of non-metals: H_2 , O_2 , F_2 , Cl_2 and alkalis are obtained in this way.



The chemical activity of metals decreases and the reducing activity of metal ions increases \rightarrow . $J, Br, S^{-2}, Cl, OH, NO^{-3}, SO^{-2}_4, PO^{-3}_4 \rightarrow$ Oxidation activity is reduced. When a solution of NaCl in water is electrolyzed, sodium metal is released at the cathode, and chlorine gas is released at the anode. Currently, metals and non-metals such as Mg, Ca, Na, Cl_2, O_2, N_2 are obtained in this way.

The efficiency of hydrogen production by water electrolysis is too low to be economically competitive due to high energy consumption and low hydrogen release rate. Therefore, in order to improve efficiency and reduce energy consumption, many researchers have developed low-cost electrocatalysts and worked on reducing efficiency and energy. Water electrolysis is one of the most efficient methods of hydrogen production. In addition, the electrolysis process uses continuous power from sustainable energy sources such as solar, wind and biomass. But currently, only 4% of hydrogen can be produced by electrolysis of water, mainly due to economic problems. Despite the increase in the use of renewable energy sources (solar, wind, nuclear), this value is expected to increase in the near future.

Summary. Based on the above, it can be explained that electrolysis is carried out with a number of dependencies and special tools and equipment. In particular, the electrolysis process is studied in devices such as electrolyzers, electrolysis baths, and various methods. Some information was given about the areas where products obtained as a result of electrolysis are used. One of the most necessary parameters for fully understanding this process is the activity range of metals, which was proposed by the Russian scientist N.N. Beketov. Metals can be distinguished from each other by their electrochemical voltage series, which basically corresponds to their displacement series. These data and learning processes were carried out on the basis of mutual differentiation.

REFERENCES

1. Alimova F. A. Information technologies as a form of visual presentation of educational information //British View. - 2022. - T. 7. – no. 4.
2. Shomurotova S. Kh. Improvement of chemistry teaching methodology in higher education organizations based on innovative approaches. - 2022..
3. Berdikulov R. S. On the integration of the rules of logic in the education of chemistry // Scientific-methodical journal of interpretation and research. – 2022. – no. 1. – S. 82-85.
4. Alimova F. A. Obuchenie temy "metal corrosion" na osnove proektnoy tekhnologii //Innovatsii v pedagogike i psikhologii. - 2022. - T. 5. – no. 2.
5. Temirov N. O., Mirkomilov Sh. M., Alimova F. A. K voprosu ob obuchenii praktonom znachenii metallov //BBC 94 Z 40. – S. 46
6. B.V. Nekrasov. Basic chemical chemistry. T. 1.2 M. Chemistry, 1973.
7. G. Remi Course inorganic chemistry. M. Mir, t. 1,2 1963. 1966 gg.
8. N.S. Axmetov. Obshchaya i inorganicheskaya khimiya. M. "Vysshaya" school" 1987
9. Yes. A. He is the same. General chemistry. M. "Vysshaya Shkola", 1984
10. www.lakokraska-ya.ru
11. www.infrahim.ru/cat/lkm