International Journal of Innovation and Research in Educational Sciences
Volume 8, Issue 5, ISSN (Online) : 2349–5219

A Study of the Moroccan Students' Misconceptions about the Electrolysis

Mohamed Eddahby[1,2*], Rachid Cherouaki[1,3], Azzeddine Atibi[1,3], Bouchra Gourja[1,3], Aouatif Dezairi[2], Jamal Naja[4] and Khadija Elkababi[1,3]

[1]Regional Center for the Professions of Education and Training, Casablanca-Setta-Settat, Morocco.
[2]Laboratory of Condensed Matter Physics (URAC10), Faculty of Science Ben M'Sik, University Hassan II-Mohammedia Casablanca, Morocco.
[3]Physical Chemistry Laboratory of Materiels, Faculty of Science Ben M'Sik, University Hassan II-Mohammedia Casablanca, Morocco.
[4]Department of Chemistry, Sciences and Technologies Faculty, University Hassan 1er, Settat, Morocco.
*Corresponding author email id: mohamededdahby@gmail.com

Date of publication (dd/mm/yyyy): 01/11/2021

***Abstract* – The main actors in the Educational Process are the students and teachers, each of them has a role and a responsibility to fulfill. The implementation of several basic knowledge acquires a new dimension due to the need of transpose them into learning environments. The didactic transposition characterizes the gap between the reference knowledge (scholarly and cultural knowledge of society), the knowledge to be taught and then the knowledge taught. The analysis of the transition from knowledge to be taught to knowledge taught must cover both curricula, commentaries, textbooks, course. The concepts of electrolysis and cell galvanic are axial in the curricula of physical sciences in secondary schools in the Moroccan educational system. In this context, the aim of this paper is to study some misconceptions of Moroccan students about the process of electrolysis and galvanic cells. The findings, of this research has put the emphasis on some Moroccan student misconceptions to detect the main difficulties that prevent the evolution of students' acquisition.**

***Keywords* – Electrolysis, Galvanic Cells, Electrolytic Process, Reaction Quotient, Anode, Cathode.**

I. INTRODUCTION

Electrolysis has many industrial applications such as chromium plating, galvanizing (Hongxia Wan, Yong Cai, Dongdong Song, Tingting Li [1]), for protection against corrosion, the preparation of chlorine, the manufacture of soda from sea salt. The production of aluminum by electrolysis is the process which makes it possible to manufacture aluminum metal from alumina extracted from bauxite. For the production of hydrogen and dioxygen by electrolysis of water (Khamis Youssef, Ahmed Hussien [2]) using an electric current. During electrolysis, we generally speak of cathodic reduction and anodic oxidation (M. Comtat, G. Loubet, J. Mahenc [3]), due to the electrodes which are the seat of chemical reactions and the transfer of electrons thanks to a generator. Electrolysis can provide relatively stable electricity (Yanchao Jin, Jianling Fu, Riyao Chen, Qiuting Zhang, Yaoxing Liu) [4], since there is an increase in temperature or expansion of the anode zone which could improve electricity production by an electrochemical reactor (Andre Tschope, Maximilian Wyrwoll, Michael Schneider, Karl Mandel, Matthias Franzreb [5]) which has formed a cell made up of two conductive metal electrodes. Across this set applied a potential difference. Other factors influence the selectivity of electro chemical reactions, including control of the composition, concentration, conductivity (M.N. Palatnikov, A.V. Yatsenko, V.A. Sandler,N.V. Sidorov, O.V. Makarova, D.V. Manukovskaya [6]), temperature and pH of the electrolyte.

Several authors have recently studied the basic electrolysis concepts. D.T. Sia and al developed a two-tier multiple choice diagnostic instrument consisting of 17 items to evaluate students' understanding of basic electrolysis concepts (D.T. Sia [7]) D.F. Treagust, D.T. Sia and A.L. Chandrasegaran developed a study to assess high school chemistry students' understanding of 19 major principles of electrolysis using a recently developed 2-tier multiple-choice diagnostic instrument (D.T. Sia, D.F. Treagust and A.L. Chandrasegaran [8]) However, to develop this knowledge, we have used a new educational approach to help students build satisfactory representations of the evolution of Chemical systems in multiple circumstances.

From where we will try to highlight the maximum of gaps and nuance the differences between a spontaneous reaction and a forced reaction during a chemical transformation and the set of problems emanating from this confusion. Subsequently, we will carry out a verification of the acquired knowledge and detect false conceptions in the learners using a questionnaire, then measure the rate of effectiveness of the approach taken.

Finally, we will try to bring out the main causes responsible for these conceptions and propose solutions that could put an end to these confusions. The second section presents an overview about the methodology, target population and the questions raised about the subject. The third section describes the findings of this work.

II. Research Context and Methodology

A. *Working Approach*

The research methodology consists in the collection of data by using multiple-choice questions including ended and opening questions.

We therefore think that the fact of using this type of questionnaire will give us more relevant information on how the learners' conceptions are structured. The teacher will then classify and use them easily to provide the best possible education for learners.

B. *Population Studied*

This research aims to identify the different types of students' conceptions from the second year of high school, section physical chemistry, chemistry, the third topic (Evolution direction of a chemical system), which allow us to improve the quality of education to ensure that the students could have a more elaborate scientific knowledge. So, we took a sample of 150 students from three different schools in the region of Casablanca. The table below sets out the high schools chosen for this research and the number of students:

Table 1. Number of students and high schools selected for the research.

High Schools	Number of Students
High school Jaafar Elfassi (Casablanca, moulay rachid)	160
High school le CEDRE (Casablanca Anfa)	40
Total	200

C. *Questionnaire*

Our research is focused on the students' conceptions about the electrolysis, we developed 15 questions concerning our subject of study. We have used all of them to develop our questionnaire (Appendix 1).

III. Results and Discussion

We classified the responses of students in three categories: Category of correct answers, wrong answers, and absence of response. To assess student learning, we have summarized their responses in the table below.

International Journal of Innovation and Research in Educational Sciences
Volume 8, Issue 5, ISSN (Online) : 2349–5219

Thus, to analyze the results of the questionnaire responses, we have established, in Fig. 1, a comparison histogram of questionnaire responses according to the frequency of occurrence of each category.

Table 2. Answers to the evaluation questions.

N° of Question	Correct Answers	Wrong Answers	Absence of Response
Question 1	65,00%	35,00%	0,00%
Question 2	42,00%	45,00%	12,50%
Question 3	75,00%	25,00%	0,00%
Question 4	55,00%	35,00%	10,00%
Question 5	45,00%	55,00%	0,00%
Question 6	35,00%	60,00%	5,00%
Question 7	70,00%	30,00%	0,00%
Question 8	40,00%	47,50%	12,50%
Question 9	38,00%	52,00%	10,00%
Question 10	39,50%	50,50%	10,00%
Question 11	49,00%	46,00%	5,00%
Question 12	35,00%	60,00%	5,00%
Question 13	64,00%	31,00%	5,00%
Question 14	62,00%	33,00%	5,00%

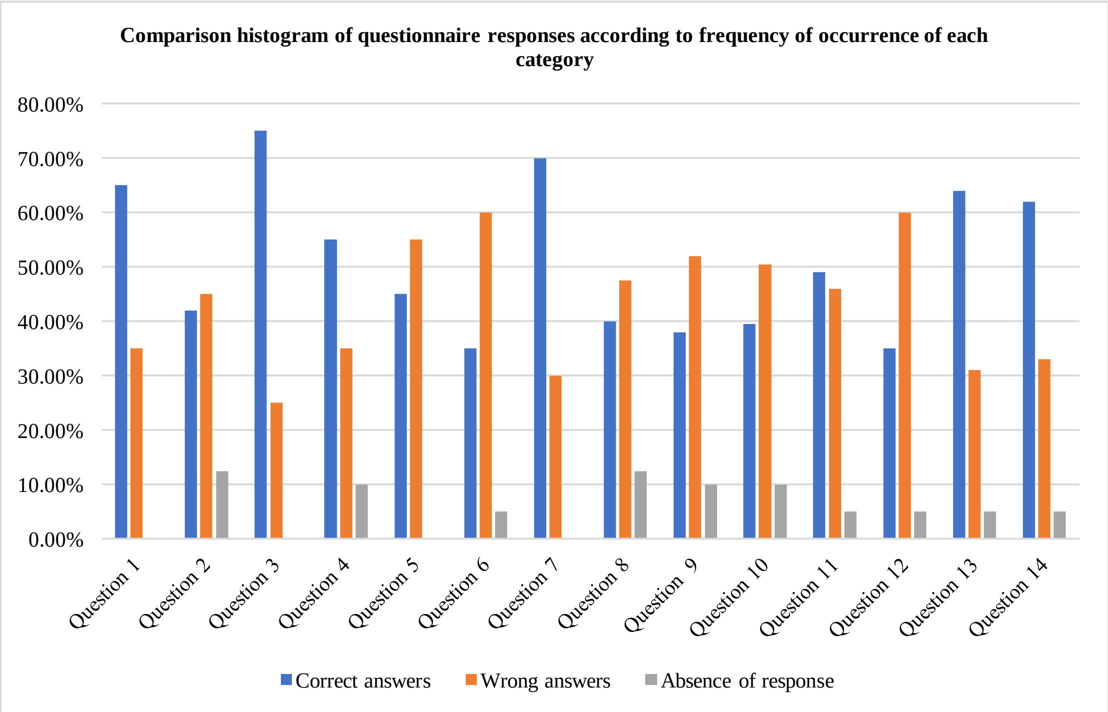

Fig. 1. Comparison histogram of questionnaire responses according to frequency of occurrence of each category.

The results of the answers to question 1 show that the rate of correct answers is 65% against 35% for all the wrong answers and without answer, this means that more than third of the questioned students have an obstacle of general knowledge, in fact, the status of a reversible reaction is conveniently assessed by evaluating its reaction quotient (Q). For a reversible reaction described by $mA + nB \rightleftharpoons xC + yD$, the reaction quotient is derived directly from the stoichiometry of the balanced equation as $Qc = \frac{[C]^x .[D]^y}{[A]^m .[B]^n}$, where the subscript c denotes the use of molar concentrations in the expression (P. FLOWERS, K. THEOPOLD and all [9]). The student does not focus that the equation of reaction show only the components in the gaseous or aqueous states. We notice that 58 % of the answers of the question 2 are wrong what shows that the majority of the students confuse the term rate of a reaction at any particular point in time with the term instantaneous rate of reaction as it starts. More than half of the questioned students have an obstacle of general knowledge, in fact, the instantaneous rate is the rate of a reaction at any point in time, a period that is so short that the concentrations of reactants and products change by a negligible amount. The initial rate is the instantaneous rate of reaction as it starts (as product just begins to form). Average rate is the average of the instantaneous rates over a time (Juan Quilez [10]). For question 3, an important percentage of the correct answers (75 %) reflects the good knowledge of the students about the Chatelier's principle, in fact, when a chemical system at equilibrium is disturbed, it returns to equilibrium by counteracting the disturbance. The disturbance causes a change in Qr; the reaction will shift to re-establish Qr = K. According to the question 4 we notice that more than half of the students had a correct answer and can describe the function of a galvanic cell and its components. The results of the answers to question 5 show that the rate of correct answers is 45% against 55% for all the wrong answers and without answer, this means that half of the questioned students do not focus on the difference between anode and cathode of an electrochemical cell, the confusion can be cleared up by defining the anode and cathode in terms of the actual chemical reactions-the oxidation and reduction reactions-that are taking place inside the cell, whether the cell is generating electricity as a galvanic cell or consuming it as an electrolytic cell. We notice that 60% of questioned students think that the electrode that lose mass as the oxidation-reduction reaction was allowed to proceed is the cathode. Most of the questioned students have an obstacle of general knowledge, in fact, active electrodes participate in the oxidation-reduction reaction. Since metals form cations, the electrode would lose mass if metal atoms in the electrode were to oxidize and go into solution. Oxidation occurs at the anode. We notice that a majority of the students assert that the salt bridge in galvanic cell is necessary, in fact, Without the salt bridge, the circuit would be open (or broken) and no current could flow. With a salt bridge, each half-cell remains electrically neutral and current can flow through the circuit. According to the questions 8, 9 and 10, we notice that more than half of the students had a wrong answer, this means that more than half of the questioned students do not focus on the convention of cell schematic, in fact, by convention, the schematic begins with the anode and proceeds left-to-right identifying phases and interfaces encountered within the cell, ending with the cathode. The correct responses rate of the questions 11 does not exceed 49%, which explains that the concepts of anode and cathode are often accompanied by misconception, in fact, the negatively charged electrode will attract positive ions (cations) toward it from the solution. It can donate some of its excess electrons to such cations or to other species in the liquid being electrolyzed. Hence this electrode is in effect a reducing agent. In any electrochemical cell (electrolytic or galvanic) the electrode at which reduction occurs is called the cathode. The equations for reactions, taking place at the anode and the cathode, does make some problems since the rate of true answers represents 35% of Question 12, which explains that the electrolysis phenomena are often accompanied by misconceptions. In fact, an important percentage of questioned students could have a problem in identifying the ions which were selectively discharged at the anode and cathode during the electrolysis process. Finally, it is noticeable that the quantity of electricity and the charge transferred, in electrolysis, are normal and does not make any problems since the rate of true answers exceed represents 60% of Questions 13 and 14.

III. CONCLUSION

The concepts of electrolysis and cell galvanic are axial in the curricula of physical sciences in secondary schools in the Moroccan educational system. In this context, we have detected and analyzed some misconceptions of Moroccan students about the process of electrolysis, galvanic cells, and the stoichiometric calculations for electrolytic process.

The findings, of this work, showed that the lack of basic knowledge in the topic of fundamental equilibrium concepts and electrochemistry resulted in the questioned students not being able in solving the questions in the open-ended electrochemistry assessment. We also discovered that some students in this study applied rote learning whereby they memorized the concepts in fundamental equilibrium concepts and electrochemistry without understanding the concepts in this topic. In fact, among the nuances detected by analyses of answer of questionnaire, we can mention:

Difficulty to identify the oxidant and reductant of a redox reaction

Difficulty to balance a chemical equation for redox reactions.

Difficulty to give the concentration-based reaction quotient expression

Difficulty to describe the function of a galvanic cell and its components

Difficulty to use a schematics of galvanic cells.

Language obstacles (terminological difficulties), contributed to students' misconceptions. According to J. Quilez [10], students meet a terminological difficulty when learning chemistry.

Among the main issues of technical terms are the following: new coined specific terms of chemistry, daily and scientific meanings, mathematical terms, and dual concepts.

In summary, the contribution of this research has put the emphasis on some Moroccan student misconceptions to detect the main difficulties that prevent the evolution of students' acquisition. The teachers must interact with the misconceptions of students, using the method of "to do with so as to go against", to lead students to formulate other realistic conceptions. This research will be able to serve as a guideline for the teachers to look in depth into the students' difficulty in mastering the topic of fundamental equilibrium concepts and electrochemistry.

Table. Appendix 1.

Question	Correct Answer
1/ The status of a reversible reaction is conveniently assessed by evaluating its reaction quotient	

Question	Correct Answer
(Qr). For a reversible reaction described by: $aA(aq) + bB(l) \rightarrow cC(aq) + dD(s)$ the reaction quotient is derived directly from the stoichiometry of the balanced equation as: $Qr = \frac{[C]^c}{[A]^a}$ or $Qr = \frac{[C]^c.[D]^d}{[A]^a.[B]^b}$ or $Qr = \frac{[A]^a}{[C]^c}$	
2/The instantaneous rate is: the rate of a reaction at any particular point in time or the instantaneous rate of reaction as it starts	
3/ The constant value of Q exhibited by a system at equilibrium is called the equilibrium constant, K: The reaction will proceed in the reverse direction if: Qri = K or Qri> K or Qri <K	
4/ Among the following elements: choose those which are essential for the realization of a pile: Electrodes, Resistance, A salt bridge, Electrolyte solutions, voltage source.	
5/ The anode of an electrochemical cell is the electrode at which: Oxidation occurs or reduction occurs.	
6/An active (metal) electrode was found to lose mass as the oxidation-reduction reaction was allowed to proceed. Was the electrode part of the anode or cathode?	
7/ a salt bridge in galvanic cells, based on the spontaneous reaction, comprised of two half-cells separed, is: Necessary or not necessary	
8/ Assuming the schematics below represent galvanic cells as written, identify the half-cell reactions occurring in each. (a) $Mg_{(s)} \| Mg^{2+}_{(aq)} \|\| Cu^{2+}_{(aq)} \| Cu_{(s)}$ (b) $Ni_{(s)} \| Ni^{2+}_{(aq)} \|\| Ag^{+}_{(aq)} \| Ag_{(s)}$	
9/Assuming the schematics below. $Ni_{(s)} \| Ni^{2+}_{(aq)} \|\| Ag^{+}_{(aq)} \| Ag_{(s)}$ What species is being oxidized and what species is being reduced.	
10/ Omitting solute concentrations and spectator ion identities, write the schematic for a galvanic cell whose net cell reaction is shown below. $Sn^{4+}_{(aq)} + Zn_{(s)} \rightarrow Sn^{2+}_{(aq)} + Zn^{2+}_{(aq)}$	
11/ In electrolysis, The negatively charged electrode is: The anode or the cathode.	
12/ in the Electrolysis of Molten Sodium Chloride process, Write the half equations for reactions taking place at the anode and the cathode respectively.	
13 /The charge transferred, Q, by passage of a constant current, I, over a specified time interval, t, is given by the simple expression: $Q = I.t$ or $Q = \frac{I}{t}$ or $Q = \frac{t}{I}$	
14/ The amount of substances formed at the anode or cathode can be calculated from the magnitude of current (in amperes) and time (in seconds) of electrolysis. The expression corresponds to the quantity of electricity is: $Q = n(e^-).F$ or $Q = \frac{n(e^-)}{F}$ or $Q = \frac{F}{n(e^-)}$	

REFERENCES

[1] H. Wan, Y. Cai, D. Song, T. Li, "Investigation of corrosion behavior of Mg-6Gd-3Y-0.4Zr alloy in Xisha atmospheric simulation solution", Ocean Engineering, Volume 195, 1 January 2020, 106760.

International Journal of Innovation and Research in Educational Sciences
Volume 8, Issue 5, ISSN (Online) : 2349–5219

[2] K. Youssef, A. Hussien, "Electrolyzed water and salt solutions can reduce green and blue molds while maintain the quality properties of 'Valencia' late oranges" Postharvest Biology and Technology, Volume 159, Article 111025, January 2020.
[3] M. Comtat, G . Loubet, J. Mahenc, "Study of some redox properties of the molten potassium sulfate-disulfate eutectic mixture" Journal of Electro analytical Chemistry and Interfacial Electrochemistry, Volume 40, Issue 1, Pages 167-178, November 1972.
[4] Y. Jin, J. Fu, R. Chen, Q. Zhang, Y. Xing, "Ammonium and phosphorus recovery and electricity generation from mariculture wastewater by the seawater battery", Energy Conversion and Management, Volume 160, March 15, 2018, pp. 396-402.
[5] A. Tschöpe, M. Wyrwoll, M. Schneider, K. Mandel, M. Franzreb," A magnetically induced fluidized-bed reactor for intensification of electrochemical reactions" Chemical Engineering Journal, Volume 385, 1 April 2020, 123845.
[6] M.N. Palatnikov, A.V. Yatsenko, V.A. Sandler, N.V. Sidorov, O.V. Makarova, D.V. Manukovskaya, "Dielectric properties and electrical conductivity of LiNbO3: Zn crystals in the temperature range 310–900 K ", Solid State Ionics, Volume 345, Item 115178, February 2020 .
[7] D.T. Sia, Development and application of a diagnostic instrument to evaluate secondary school students, conceptions of electrolysis, thesis, Curtin University of Technology, July 2010.
[8] D.T. Sia, D.F. Treagust and A.L. Chandrasegaran, "High school students' proficiency and confidence levels in displaying their understanding of basic electrolysis concepts", International Journal of Science and Mathematics Education, volume 10, pp.1325–1345, 2012.
[9] P. Flowers, K. Theopold and all Stringer. Chemistry: Atoms First 2e, OpenStax, Rice University, Houston, Texas 77005. 2019
[10] J. Quílez, "A categorisation of the terminological sources of student difficulties when learning chemistry", Studies in Science Education, 55:2, 121-167, Ward, L. (2009). 2009 Breakthrough awards. Popular Mechanics, 186(11), 2019, pp. 62-73.

AUTHOR'S PROFILE

First Author
M. Eddahby born in 1976 in Casablanca, Morocco, had a degree of PHD in plasma physics on December 2007 from the faculty of sciences ben M` sick, Casablanca, Morocco. Pr. Eddahby is a professor in regional center for the professions of education and training, Casablanca- Settat, since 2011. He is a member of laboratory of condensed matter, faculty of sciences ben M` sick. He is also member of MACOMS (Pole of competence Condensed Matter and Modelling Systems) since 2003.

Second Author
R. Cherouaki born at 1970 in Casablanca , Morocco, had degree of PHD in chemistry application and environment in 2015 from the faculty of Sciences and Technology Settat 577. Morocco. Pr. R**.** Cherouaki is a professor in Regional Center for the professions of education and training, Casablanca - Settat, Morocco, since 2020. He is a member of Applied Chemistry and Environment Laboratory. Faculty of Science and Technology Settat 577. Morocco since 2008.

Third Author
A. Atibi born at 1965 in eljadida , Morocco, had degree of PHD in chemical physics in 2003 from the faculty of Science sciences ben M'sick, Casablanca, Morocco. Pr. Atibi is a professor in Regional Center for the professions of education and training, Casablanca - Settat, Morocco, since 2013. He is a member of member of laboratory of applied chemistry and environment, faculty of sciences ben M` sick.

Fourth Author
B. Gourja born at 1961 in Rabat, Morocco, had a degree of PHD in phosphates in physical chemistry in Avril 2017 from the faculty of sciences Ben M'Sick, Casablanca, Morocco. Pr. Gourja is a professor in Regional Center for the professions of education and training, Casablanca - Settat, Morocco, since 1991. She is a member of laboratory of physical chemistry, faculty of sciences Ben M'Sick.

Fifth Author
A. Dezairi born at 1959 in casablanca, Morocco, had a degree of PHD in plasma physics in July 1989 from the Brussels –Belgium. Pr A.Dezairi is a professor in faculty of sciences ben M'sick, Casablanca, since 1990. She is a member of laboratory of condensed matter, faculty of sciences ben M'sick. She is also member of MACOMS (Pole of competence Condensed Matter and Modelling Systems) since 2001.

Sixth Author
J. Naja born at 1961, had had a degree of PHD in physical chemistry in 1992 from the Poitiers university French. Pr. Naja is the head of the faculty of Sciences and Technology Settat 577, Morocco.

Seventh Author
K. elkababi born at 1971 in Casablanca, Morocco, had degree of PHD in chemical physics in 2000 from the faculty of sciences ben M` sick, Casablanca, Morocco. Pr. elkababi is a professor in Regional Center for the professions of education and training, Casablanca - Settat, Morocco, since 2011. He is a member of member of laboratory of applied chemistry and environment, faculty of sciences ben M'sick