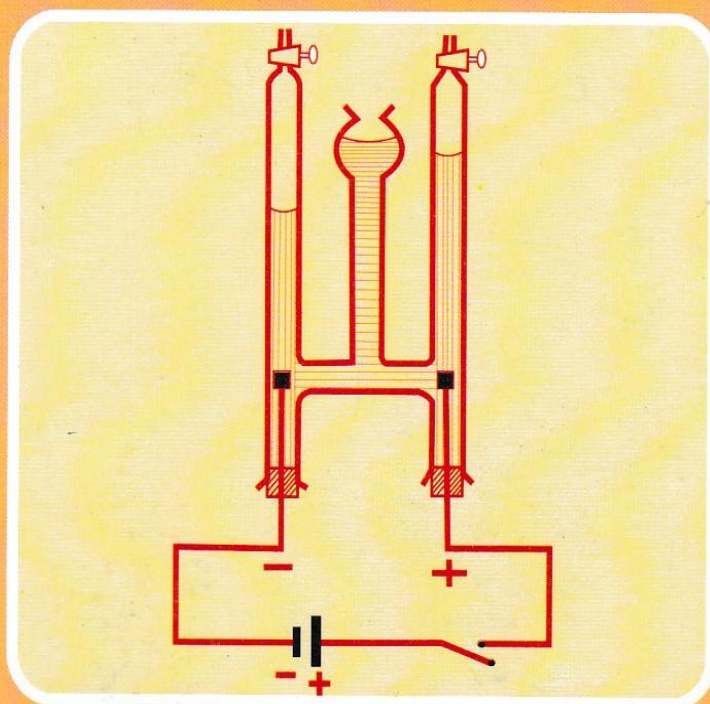


**SCIENCE TEACHERS
ASSOCIATION OF NIGERIA**

CHEMISTRY PANEL SERIES 6

**TEACHING
ELECTROCHEMISTRY**



**A HANDBOOK FOR
CHEMISTRY TEACHERS**

EFFECTIVE USE OF PROBLEM –BASED LEARNING IN THE TEACHING OF ELECTROLYSIS.

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Introduction

Electrolysis is essentially a practical-oriented chemistry concept that demands proper exhibition of observational and mathematical skills for effective interpretation of existing chemical phenomena. Available data and evaluation of Chief Examiners' reports of every year has revealed very poor performance of students in chemistry, particularly on electrolysis. Akpan (1999) observed that lack of practical work by chemistry students has resulted in poor communication and observational skills giving rise to students' poor performance. Njelita (2005) identified that chemistry teachers' classrooms were extremely theoretical, teacher-dominated, and didactic approach were mainly used which encourage rote-learning and memorization of facts; as such, chemistry teachers are to be blamed to a certain extent as contributing to students' poor performance. Many teachers and students of chemistry consider electrolysis as a difficult concept due to its abstract nature and so are scared when it comes to calculations involving electrolysis. The approaches and pedagogies employed to deliver the course content by the teacher may also be a root cause of low performance by the students.

Teaching method varies from one teacher to the other. Teaching resources for learning, the environment for learning play vital roles in exposing learners to hands-on activities that will aid in acquiring practical and observational skills in electrolysis. It is important that effective method that is student-centred and activity-based be used to facilitate learners' acquisition of problem-solving skills in electrolysis. This problem can be solved and made simple to teachers and students' understanding if an appropriate teaching strategy like problem-

based learning (PBL) is used. This paper therefore, tries to reduce the teaching-learning difficulties inherent in the concept 'electrolysis' by providing useful guidelines on how to teach and impart knowledge effectively for students understanding of electrolysis using problem-based learning approach.

PROBLEM-BASED LEARNING (PBL) INSTRUCTIONAL APPROACH

Problem-based learning (PBL) strategy is a simplified and natural way of learning that tries to introduce learning content in the context of complex real world problems (Duch 1996). PBL is an instructional approach that engages students' interest and motivate them to probe for deeper understanding of concept being introduced, relating it to the real world so as to make decisions based on information learned in order to solve problems. Teaching using PBL involves problem identification, group construction, provision of resource materials (such as experimental kits, books, charts, journal); framework lectures, class sessions and evaluation. The main idea behind this strategy is that the starting point for learning should be a query, a problem, a puzzle, task or trigger which the learner is expected to solve (Achuonye 2003).

Problems, activities, discussions and illustrative charts for electrochemical series, electrolytic cell set-up and periodic table were used as students' contact materials for the lesson. During the class sessions, the students in their respective small group setting discuss the topic, consult relevant resource materials and attempt solving problems. The teacher using this strategy acts only as a facilitator giving clues to the students only when the need arises and encouraging the use of group activities based on the students' previous knowledge. In the small group setting, each

member of the group through effective class interaction, cross fertilization of ideas, researches and role assignments carry out activities and make observations while the activity is going on and discuss the observation among themselves. When an agreement is reached on an observation, it is recorded. The teacher moves from one group to another, listening to their discussions, observe their attempts, answer their questions (usually with other questions) that will point the discussion in the right direction. At the end, the teacher leads a general class discussion. A step-by-step presentation is involved in presenting Problem-based learning (PBL).

Duz (2008) and Etiubon (2009) affirm that small group settings offer the best option for the teaching of mathematical based concepts in chemistry such as electrolysis. The applications of the two laws of Faraday on electrolysis hinges on:

- i. Giving correct equations of the reactions involved during an electrolytic process.
- ii. 1 mole of an electron = 1 Faraday, which is equivalent to 96500 Coulombs.
- iii. The amount, in moles, of an element or compound is the mass divided by the relative atomic mass or molar mass respectively.

Lesson Notes on Electrolysis

Subject: Chemistry

Class: SS 2

Average Class Size: 40

Average Age: 15+ years

Duration: 40 x 3 minutes (per week)

Topic: Faraday's Laws of Electrolysis

Class setting: Small group

Teaching Method:

Problem-Based Learning Approach (PBL)

Lesson Objectives

The students should be able to:

- Explain in their own words, the meaning of the concept *electrolysis*.
- State correctly Faraday's first law of electrolysis.
- State correctly Faraday's second law of electrolysis.
- Solve correctly given quantitative problems involving Faraday's laws of electrolysis.

Experimental Kit

Periodic table, electrochemical series chart, Zinc dust, Zinc granules, dilute tetraoxosulphate (VI) acid, 250 cm³ distilled water, voltmeter, copper wires, battery, bulb, crocodiles clips, silver trioxnitrate (V) solution, copper (II) tetraoxosulphate (VI), copper electrode and Zinc electrode.

Presentation

Entry Behaviour

The students had studied that when electric current is passed through a chemical compound, some of these compounds are able to conduct electricity because they dissociate into ions under the influence of electric current. The electrical current initiates a chemical reaction or a break up of bonds.

Step 1:

The teacher revises previous lesson on migration of ions to either cathode or anode and the preferential discharge of the ions using the electrochemical series chart to perceive prior knowledge of students earlier taught preceding concept. Teacher proceeds by stating the topic for the day and what the students are expected to do during and at the end of the lesson.

Content Development / Instructional Procedure :

The teacher introduces the concept 'electrolysis' and engages the students in interactive discussion acting only as a facilitator. Students attempt to make definitions, explanations and descriptions of electricity, electrolysis, electrolytes and electrodes. The students make inputs, asks questions as teacher gives clues when and where necessary. The teacher now facilitates and explain more explicitly the listed concepts of electrolysis.

Electrolysis is the chemical decomposition of compounds into their component ions by the passage of electric current through a solution of the compound or the molten forms of such compounds that allow the passage of electricity through them. Substances that can conduct electricity can only exist in fused or aqueous state and are called electrolytes while substances that can not conduct electricity in their fused or molten state are non-electrolytes. Electricity is conducted by means of ions and when a substance is dissolved in water it undergoes ionization with cations and is no more bound to the anions.

Three main factors contribute to preferential discharge of ions. These are:

- i. Position of ions in the electrochemical series,
- ii. nature of the electrode;
- iii. the relative concentration of the ions.

Step 2 :

State correctly Faraday's first law of electrolysis:

The mass (m) of an element deposited or liberated during electrolysis is directly proportional to the quantity (Q) of electricity passed.

$$m \propto Q$$

where **m** = mass deposited, in grams;

Q = quantity of electricity passed, in coulombs.

Quantity of electricity, $Q = \text{current, } I \times \text{time, } t$
 $= I t$

Therefore, $m \propto I t$.

Introducing proportionality constant Y

$$m = Y I t$$

Y is made the subject of the formula thus :

$$Y = m/It$$

Y represents the reciprocal of the charge to mass ratio; thus the equation can now be written as:

$$1/Y = It/m$$

This underlying basis of Faraday's first law mathematical derivation should be the foundation the teacher enforces to enrich students knowledge of the first law of electrolysis. Emphasis should be also on the fact that: the amount of substance obtained during electrolysis depends on:

- the magnitude of the current in ampere,
- the time in seconds the current is passed, and
- the charge on the ion.

It should be noted that the quantity of electricity needed to deposit one mole of any substance during electrolysis; is the charge on the ion multiplied by one Faraday (1F) which is ($c \times F$)

Teacher Activity

The teacher gives students a mathematical consideration to attempt and learn how to tackle a problem using PBL techniques in Faraday's first law of electrolysis.

Problem 1:

Copper (II) tetraoxosulphate (VI) is electrolyzed using platinum electrodes. A current of 0.193 A is passed for 2 hours. How many grams of copper are deposited?

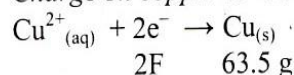
Students' Activity with PBL probe questions:

- What is the charge on the copper?
- What is the time taken for the flow of electric current?
- What is the quantity of electric current consumed for the deposition of copper?
- What mass of copper is deposited?

Students attempt solving the given problem following given PBL guidelines.

Solution:

- a. Charge on copper is +2.



- b. Time = 2 hr. = $2(60 \times 60) \text{ s} = 7200 \text{ s}$.

- c. Current = 0.193 A; $t = 7200 \text{ s}$

$$Q = I t = (0.193 \times 7200) \text{ C} \\ = 1389.6 \text{ C} = 1390 \text{ C}$$

- d. To calculate the mass of copper deposited:

This involves Faraday-mass-mole relationship.

2 Faradays or $(2 \times 96500) \text{ C}$ liberate one mole (63.6 g) of copper.

i.e. 193000 C deposit 63.5 g of Cu

$$\therefore 1390 \text{ C will deposit } (1390 \times 63.5)/193000 \text{ g} \\ = 0.457 \text{ g of Cu.}$$

Problem 2:

0.1 Faraday of electricity deposited 2.95 g of nickel during electrolysis of aqueous solution. Calculate the amount, in moles of nickel that will be deposited by 0.4 Faraday. (Ni = 59.0)

Solution:

First, calculate the mass of nickel deposited:

0.1 F deposited 2.95 g of nickel

$$0.4 \text{ F will deposit } (2.95 \times 0.4)/0.1 \text{ g} \\ = 11.8 \text{ g}$$

Then, convert the mass deposited to amount, in mole.

$$\text{Amount, in moles} = \text{Mass (g)}/\text{Molar mass (g/mol)} \\ = 11.8/59.0 \text{ mol} = 0.200 \text{ mol.}$$

Problem 3:

During the electrolysis of copper from CuSO_4 , a current of 1.05 A was passed for 1hr 55 minutes.

(Cu = 64, F = 96500 C, $c = 2$, $I = 1.05 \text{ A}$)

- Calculate the time of current flow.
- What is the mass of copper that was deposited?

Solution:

- a. Time of current flow

$$= (1 \times 60 \times 60) \text{ s} + (55 \times 60) \text{ s} \\ = (3600 + 3300) \text{ s} = 6900 \text{ s}$$

- b. To calculate the mass of copper deposited:

First, calculate the quantity of electricity, Q passed, using the expression: $Q = I t$.

$I = 1.05 \text{ A}$ (given); $t = 6900 \text{ s}$ (from a above)

Substituting: $Q = (1.05 \times 6900) \text{ C} = 7245 \text{ C}$.

Then, use the Faraday-mass-mole relationship. Given that charge on Cu, $c = 2$; Cu = 64, and 1F = 96500C.

2 F will deposit 1mole of Cu.

i.e. $2 \times 96500 \text{ C}$ will deposit 64 g of Cu.

$$\therefore 7245 \text{ C will deposit } (64 \times 7245)/(2 \times 96500) \text{ g} \\ = 2.40 \text{ g of Cu.}$$

Alternative (Formula) Method:

The general mathematical formula for the 1st law of electrolysis is:

$$\frac{It}{m} = \frac{cF}{M}$$

where $It = 7265 \text{ C}$; charge on Cu, $c = 2$; Faraday, $F = 96500 \text{ C}$; for Cu, molar mass $M = 64 \text{ g/mol}$; mass, m is the required variable.

Rearranging, making m the subject of the formula and substituting:

$$m = \frac{M \times I t}{c F} = \frac{64 \times 7245}{2 \times 96500} = 2.40 \text{ g}$$

For solving problems on Faraday's second law of electrolysis; the same procedure as applicable in PBL techniques is followed.

Teacher Activity:

Teacher gives few problems relating to Faraday's second law of electrolysis and allow students to attempt.

Students' Activity with PBL probe questions:

A given quantity of electricity was passed through two cells connected in series containing Cu^{2+} ion and Ag^+ ion respectively. 0.64 g of Cu was deposited in one of the cells. How much of Ag was deposited in the other cell? ($\text{Cu} = 64$, $\text{Ag} = 108$, $F = 96500$ C).

- What are the charges of the given ions?
- What mass of Ag was deposited in the other cell?
- Calculate the quantity of electricity that was flowing?

Solution:

a. The charge on Cu is +2, while that on Ag is +1.

b. To calculate the mass of Ag deposited.

Faraday's 2nd law involves inverse proportion.

Since the charge on copper is +2, while that Ag is +1; it means for every one mole of Cu deposited, two moles of silver will be deposited at the same time.

i.e. 1 mol (64.0g) of Cu \equiv 2 mol (2×108)g of Ag.
64.0 g of Cu \equiv 216 g of Ag.

\therefore 0.64 g of Cu \equiv $(216 \times 0.64)/64.0$ g of Ag
 $= 2.16$ g of Ag.

c. To calculate the quantity of electricity passed

With respect to Ag:

1 F (96500) C will deposit 1 mole (108 g) Ag

i.e. 108 g of Ag require 96500 C.

\therefore 2.16 g of Ag require $(96500 \times 2.16)/108$ C.
 $= 1930$ C.

Problem 2:

Calculate the mass of lead that would be deposited from a solution of lead (II) trioxonitrate (V) by the same quantity of electricity depositing 1.35 g of copper.

(Cu=63.5, Pb = 207)

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a. What is the charge on lead?

b. What is the charge on copper?

c. Calculate the mass of lead deposited?

Solution:

a. $\text{Pb}^{2+}_{(\text{aq})} + 2\text{e}^- \rightarrow \text{Pb}_{(\text{s})}$

b. $\text{Cu}^{2+}_{(\text{aq})} + 2\text{e}^- \rightarrow \text{Cu}_{(\text{s})}$

2 F deposit 63.5 g (1 mol) of Cu; also 2 F deposit 207 g (1 mol) of Pb.

i.e. 63.6 g of Cu \equiv 207 g of Pb.

\therefore 1.35 g of Cu \equiv $(207 \times 1.35)/63.6$
 $= 4.35$ g.

Recommendations

- Chemistry materials should be reviewed and modified for alternative teaching strategies that will facilitate students' knowledge of chemistry concepts, particularly those involving mathematical concepts.
- Problem-based learning strategy should be adopted by chemistry teachers, to enhance students' interaction in electrolysis for ease of solving mathematical problems.
- Information update is needed by chemistry teachers on use of appropriate strategies in enhancing mathematically manipulatable concepts in chemistry by way of attending conferences, seminars and workshops.
- Day-to-day activities that engage the minds, hearts and brains of the students should be effectively implemented during practical activities involving electrolysis.

Conclusion

Teaching strategy employed by a teacher is a major contributory factor to the effectiveness of the teaching of electrolysis. Problem-based learning, which involves problem-solving, particularly those of mathematical skills, can enhance learner's participation in the instructional problem; since problems are used as tasks to motivate and arouse students' interests towards the learning and understanding of electrolysis.

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