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VCE Chemistry $\frac{3}{4}$
Electroplating [0.15]
Workshop

Error Logbook:



New Ideas/Concepts	Didn't Read Question
Pg / Q #: _____ Notes:	Pg / Q #: _____ Notes:
Algebraic/Arithmetic/ Calculator Input Mistake	Working Out Not Detailed Enough
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Section A: Recap

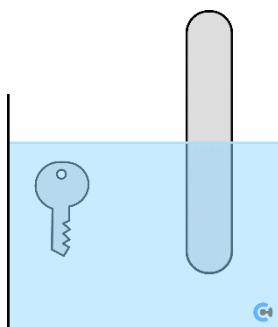


Learning Objective: [2.4.1] - Identify the electroplating setup (location of object) & find the electroplating reactions

➤ Definition:

<u>Object</u>	<u>Metal Used</u>
[Cathode] / [Anode]	[Cathode] / [Anode]
[Positive] / Negative	[Positive] / Negative

➤ Setup:



<u>Anode Reaction</u>	<u>Cathode Reaction</u>

➤ Concentration of Electrolyte:

➤ EMF:

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Learning Objective: [2.4.2] - Find next-order reactions during electrolysis



- Assume the current strongest oxidant runs out.
- Move to the next _____ oxidant.
- End game scenarios:

Learning Objective: [2.4.3] - Apply Faraday's laws to electroplating calculations



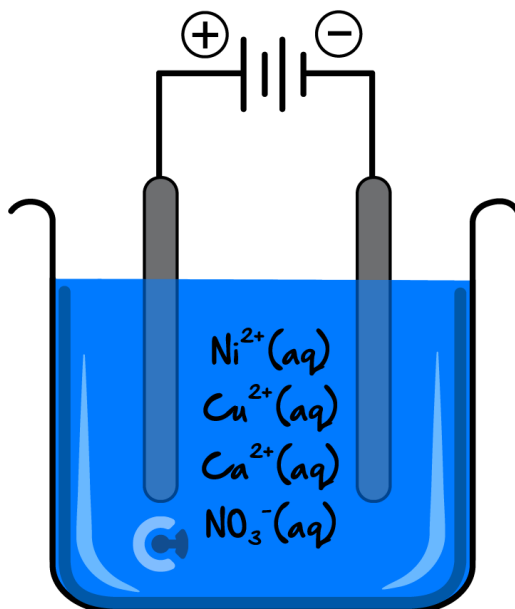
- Equations:

- Typical Steps:
 - 1.
 - 2.
 - 3.
 - 4.
- Faraday's First Law:
- Faraday's Second Law:
- **Molar Mass: Charge Ratio (M_r/z)**
 - 🔗 Use: _____ mass deposited for different metals.
 - 🔗 Formula:

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Question 1 (5 marks) Walkthrough.

Consider the electrolysis of the following electrolytic cell, which contains aqueous solutions of 0.1 M concentrations of $\text{Ni}(\text{NO}_3)_2(\text{aq})$, $\text{Cu}(\text{NO}_3)_2(\text{aq})$, $\text{Ca}(\text{NO}_3)_2(\text{aq})$ and inert electrodes:



a. Write the balanced half-equation for the reactions which occur at the:

i. Positive electrode. (1 mark)

ii. Negative electrode. (1 mark)

b. After some time has elapsed, the reaction which takes place at one of the electrodes is observed to change.

i. Write the balanced half-equation for the next reaction which takes place at this electrode. (1 mark)

ii. Write the balanced half-equation for the next reaction which takes place at this same electrode afterwards. (1 mark)

iii. Hence or otherwise, draw the products that form at this electrode. (1 mark)

Question 2 (5 marks) Walkthrough.

Michael wants to electroplate nickel metal onto his copper key chain. To do so, he attaches the positive terminal of the power source to a sheet of nickel metal, and he attaches the negative terminal to the copper key chain. The electrolyte is comprised of nickel (II) chloride.

a. Draw the electroplating cell. (1 mark)

b. Find the change in mass of the key chain, if 4.20 A of current is passed through for 15.0 minutes. (4 marks)

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Section B: Warm Up (16 Marks)

INSTRUCTION: 16 Marks. 10 Minutes Writing.



Question 3 (1 mark)

During electroplating, indicate which electrode each material should be placed at.

Object to be plated (e.g. key)	Metal used for electroplating
[cathode] / [anode]	[cathode] / [anode]
[positive] / [negative] terminal	[positive] / [negative] terminal

Question 4 (2 marks)

- a. If a current of 3.30 mA is run for 2.00 days, determine the amount of charge which passes through the wire. (1 mark)

- b. 3600 mC of charge is inputted, determine the number of electrons involved. (1 mark)

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Question 5 (3 marks)

A solution of Vanadium ions is reduced at a cathode, whereby it is found that a current of 9.00 A is produced over 1 hour. It was found that 2.87 g of Vanadium metal is deposited at the negative electrode.

Find the charge of the Vanadium ions.

Question 6 (4 marks)

A solution of iron (II) nitrate is electrolysed using inert electrodes.

a. Write the half equation which occurs at the negative electrode. (1 mark)

b. The negative electrode is seen to increase in mass by 700 mg .

i. Find the amount of electrons which must have passed through the cell. (2 marks)

ii. Find the electric charge supplied by the power source. (1 mark)

Question 7 (6 marks)

The following solution of zinc (II) fluoride is electrolysed.

a. Write the half-equations which occur at the:

i. Positive electrode. (1 mark)

ii. Negative electrode. (1 mark)

b. The positive electrode is found to produce oxygen gas, while the negative electrode deposits a solid at the electrode. Compare the mass of oxygen gas produced to the mass of the solid deposited at the negative electrode. (3 marks)

c. After some time elapses, the reaction which occurs at one of the electrodes is seen to change. Write the new half-equation which occurs at this electrode. (1 mark)

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Section C: Ramping Up (14 Marks)

INSTRUCTION: 14 Marks. 11 Minutes Writing.



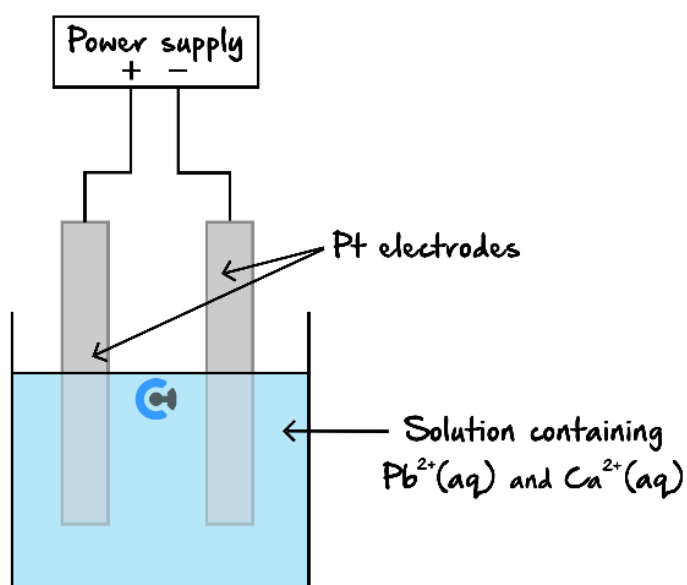
Question 8 (5 marks)



Inspired from VCAA Chemistry Exam 2005

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2005chem2.pdf#page=17>

A mineral ore contains a mixture of compounds of Lead and Calcium, in approximately equal proportions. A chemist extracts the metal ions by roasting the ore in the air. The solution that contains the $\text{Pb}^{2+}(\text{aq})$ and $\text{Ca}^{2+}(\text{aq})$ is then placed in an electrolytic cell as shown in the diagram below.



- Label the anode and cathode of the cell. (1 mark)
- When the current begins to flow in the cell, write equations for the half-reaction that is likely to occur at the:
 - Positive electrode. (1 mark)

- Negative electrode. (1 mark)

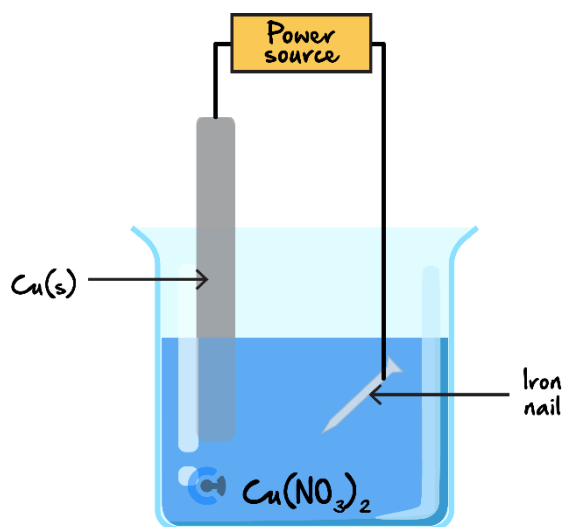
- c. After some time has elapsed, a new half-reaction occurs at one of the electrodes. Write the equation for this half-reaction. (1 mark)

- d. If the chemist had used Copper electrodes instead of Platinum electrodes, how would this have affected the half-reaction at the anode? (1 mark)

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Question 9 (9 marks)

The following setup is used to electroplate an iron nail:



- a. Explain which terminal of the power source the nail should be connected to and why. (2 marks)

b.

- i. If 2.00 A are supplied for 20 minutes, calculate the change in mass of the anode. (3 marks)

- ii. Hence or otherwise, state the change in mass of the cathode. Justify your reasoning. No calculations are necessary. (1 mark)

c.

- i. Had the cell been run for longer, but with the same current, use Faraday's laws to explain whether the change in mass observed at each electrode would be greater, lesser, or the same. (1 mark)

- ii. State the effect this would have on the change in mass of the entire cell. (1 mark)

- d. Suggest a purpose for plating the nail using copper. (1 mark)

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Section D: Getting Trickier I (12 Marks)

INSTRUCTION: 12 Marks. 10 Minutes Writing.



The following information applies to the two questions that follow

Question 10 (1 mark)

An aqueous solution was prepared by dissolving 0.1 mol of each of $\text{Sn}(\text{NO}_3)_2$, AgNO_3 , $\text{Mn}(\text{NO}_3)_2$ and $\text{Co}(\text{NO}_3)_2$ in 0.1 L of deionised water. The electrolysis of this aqueous solution was then carried out using graphite electrodes.

At the end of the electrolysis, the metal coatings deposited on the cathode in order from inside to outside are:

- A. Sn, Mn, Ag, Co
- B. Co, Sn, Ag
- C. Ag, Sn, Co, Mn
- D. Ag, Sn, Co

Question 11 (1 mark)

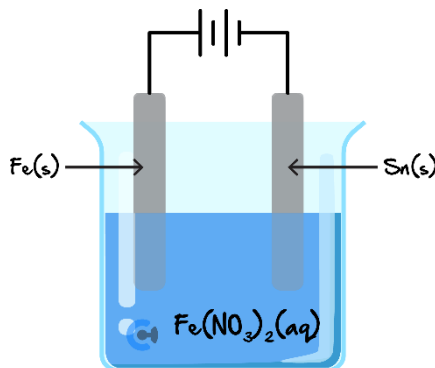
The order of increasing mass deposited at the cathode is:

- A. Mn, Ag, Sn, Co
- B. Co, Mn, Ag, Sn
- C. Mn, Co, Sn, Ag
- D. Ag, Sn, Co, Mn

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Question 12 (6 marks)

Consider an aqueous solution which contains both Fe(II) nitrate. The solution is electrolysed using a large iron anode and large tin cathode, as shown below:



a. Write the balanced half-equation for the reaction which takes place at the:

i. Cathode. (1 mark)

ii. Anode. (1 mark)

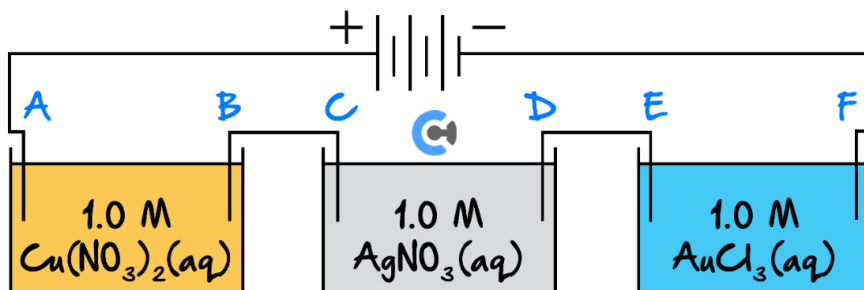
b. A fellow chemistry pirate Usopp stated, “After 2 minutes, the colour of the solution faded.”

Evaluate Usopp’s statement. Justify your answer. (2 marks)

c. After some time, the electroplating stops working. Explain this observation and draw the appearance of the cathode and anode in the diagram. (2 marks)

Question 13 (4 marks)

The connected cell given below is used, where it is found that in all three half-cells, water does not reduce at the cathode.



- a. In the middle cell, state whether electrodes *C* and *D* are cathodes or anodes. (1 mark)

Electrode <i>C</i>	Electrode <i>D</i>

- b. In the left cell, write the overall balanced equation for the reaction which occurs. (1 mark)

- c. For 15.0 minutes, 2.50 A of current is passed through.

- i. Determine which electrode (*A-F*) will have the greatest amount, in moles, of metal deposited. (1 mark)

- ii. Determine which electrode (*A-F*) will have the greatest mass, in grams of metal deposited. (1 mark)

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Section E: Getting Trickier II (9 Marks)

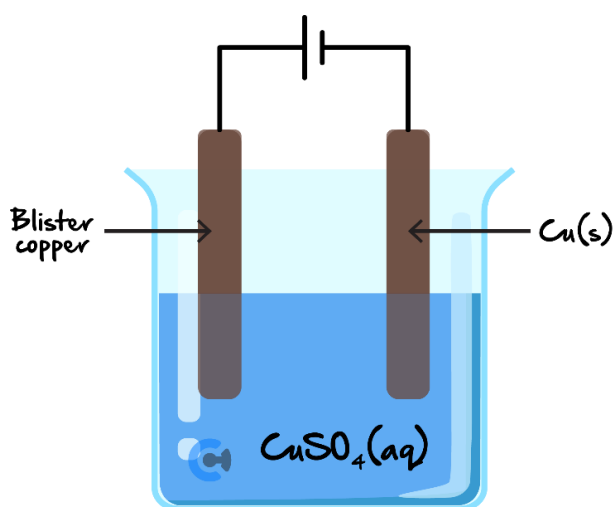
INSTRUCTION: 9 Marks. 8 Minutes Writing.



Question 14 (9 marks)

Blister copper is an impure form of copper which contains other materials such as nickel, iron, silver, cobalt, and zinc scattered throughout the blister copper.

Electro-refining copper is a method by which the impurities can be removed, which involves the following setup:



- a. State whether the blister copper functions as the anode or cathode in this cell. (1 mark)

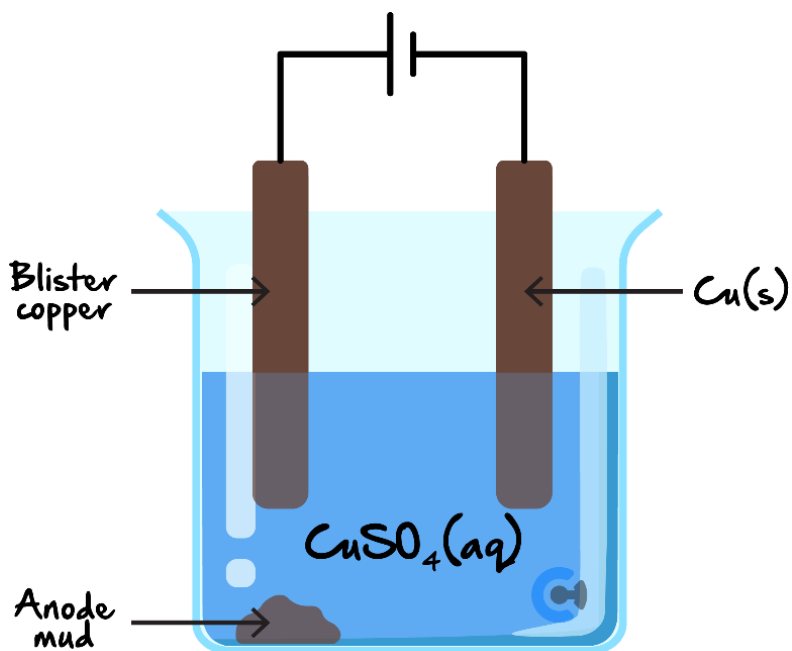
- b. Electro-refining is another version of electroplating where the negative electrode has a copper coating formed on its surface.

Write the half-equation occurring at the negative electrode. (1 mark)

- c. As this cell operates, the anode is seen to decrease in mass.

State why this is the case. Write an appropriate half-equation to justify your answer. (1 mark)

- d. Over time, a sediment is seen to form at the bottom of the beaker, known as anode mud, as shown below:



- i. Explain what this would be made out of and why it forms. (2 marks)

- ii. Given that this cell is powered with 5.5 A for 15 minutes, calculate the expected increase in mass at the cathode. (3 marks)

After some time elapses, some ions are found to be present in the electrolyte of the electrolytic cell.

- e. Apart from copper (II) ions and sulphate, list **two** other ions which will be present in the electrolyte. (1 mark)

Let's take a BREAK!



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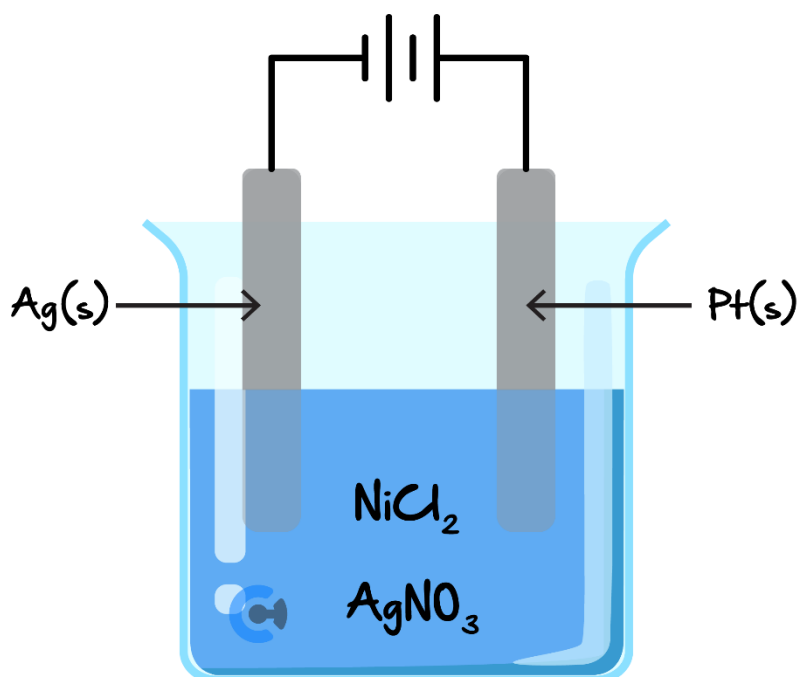
Section F: VCAA-Level Questions I (8 Marks)

INSTRUCTION: 8 Marks. 30 Seconds Reading. 8 Minutes Writing.



Question 15 (8 marks)

The following cell is constructed by passing charge through it, using 0.100 M solutions in a 50.0 mL beaker.



- a. The cell is then switched on, whereby sufficient voltage is inputted into the cell.
 - i. In the beginning, silver is deposited onto the silver electrode. Write the balanced half-equation for this reaction. (1 mark)
- ii. Explain what will happen to the concentration of silver ions in the electrolyte as the cell operates. (1 mark)

b. After the cell completely stops operating, it is seen that the cathode has increased in mass due to the formation of 2 layers on top of it.

- i.** Write the balanced half-equation for the second-order reduction reaction which occurs at the cathode. (1 mark)

- ii.** Identify what these coatings are comprised of, stating them in the order in which they form. (1 mark)

c. Calculations are then done to find the point at which silver ions completely run out in the cell. Throughout the operation of the cell, 4.80 A of current is constantly passing through the cell.

- i. Find the amount, in moles, of silver ions present at the beginning of the reaction in the 0.100 M of electrolyte, given that the electrolyte volume of electrolyte remains at 50.0 mL throughout the reaction. (1 mark)

- ii. Calculate the time taken for the silver ions to completely react. (3 marks)

- iii. If the cell runs for a total time of 200 s , find the total mass of metal deposited at the cathode.

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Section G: Multiple Choice Questions (5 Marks)

INSTRUCTION: 5 Marks. 5 Minutes Writing.



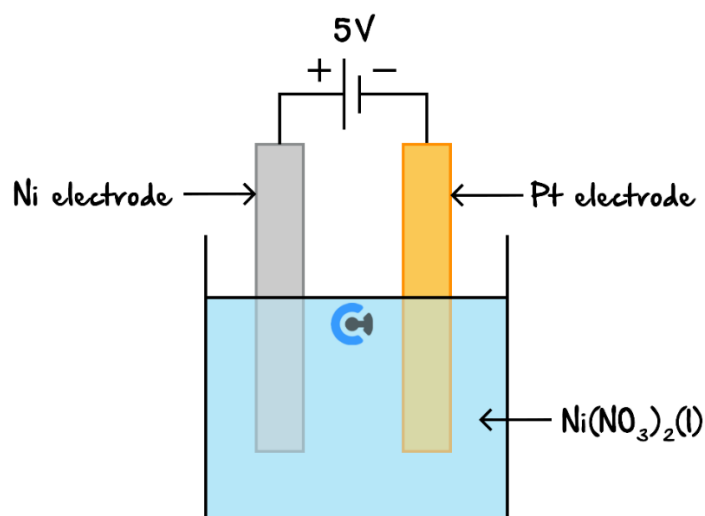
Inspired from VCAA Chemistry Exam 2021

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2021/2021chem-w.pdf#page=10>



The following information applies to the two questions that follow

An electrolysis cell with a 5 V power supply is shown below:



Question 16 (1 mark)

1 F is equivalent to the charge on 1 mol of electrons.

The mass of Nickel, Ni, that can be electroplated onto the Platinum, Pt, electrode with 320 F of charge is:

- A. $9.73 \times 10^{-2} g$
- B. $1.95 \times 10^{-1} g$
- C. $9.39 \times 10^3 g$
- D. $1.88 \times 10^4 g$

Question 17 (1 mark)

Using the electrochemical series, which one of the following changes to the electrolysis cell may reduce the amount of Ni electroplated onto the Pt electrode?

- A. Replacing the Ni electrode with a Cu electrode.
- B. Replacing $\text{Ni}(\text{NO}_3)_2(\text{l})$ with 1 M $\text{Ni}(\text{NO}_3)_2(\text{aq})$.
- C. Replacing the Pt electrode with Pb(s).
- D. Replacing $\text{Ni}(\text{NO}_3)_2(\text{l})$ with $\text{NiCl}_2(\text{l})$.

Question 18 (1 mark)


Inspired from VCAA Chemistry Exam 2021

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2021/2021chem-w.pdf#page=5>

An electrolysis cell consumed a charge of 4.00 C in 5.00 minutes. This represents a consumption of:

- A. 4.15×10^{-5} mol of electrons.
- B. 2.07×10^{-4} mol of electrons.
- C. 1.93×10^4 mol of electrons.
- D. 2.41×10^4 mol of electrons.

Question 19 (1 mark)

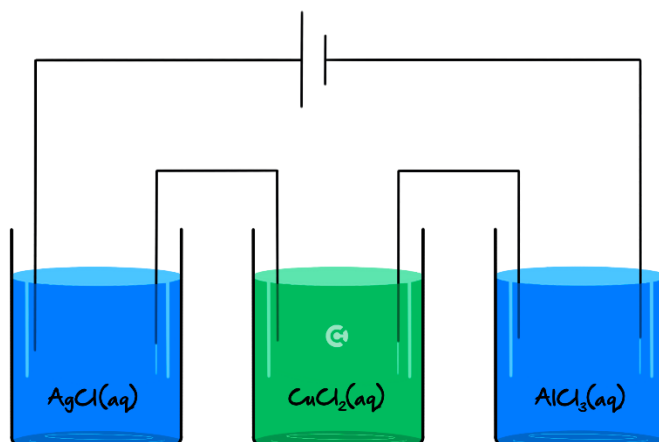
A solution of Copper ions is undergoing electrolysis using Copper electrodes. A student would observe:

- A. The anode increasing in mass and the cathode decreasing in mass.
- B. The concentration of the Copper ions staying constant.
- C. Electrons flowing from the negative to the positive electrode.
- D. The pH of the solution decreasing.

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Question 20 (1 mark)

Aqueous solutions of AgCl , CuCl_2 , and AlCl_3 are connected in series to a power supply.



After 0.60 moles of electrons have passed through this circuit, the amounts of metal deposited will be, in moles,

- A. 0.20 Ag, 0.20 Cu, 0.20 Al
- B. 0.60 Ag, 0.30 Cu, 0.20 Al
- C. 0.60 Ag, 0.30 Cu, 0 Al
- D. 0.60 Ag, 1.20 Cu, 1.80 Al

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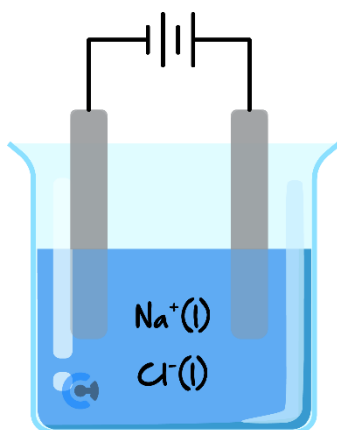
Section H: VCAA-Level Questions II (8 Marks)

INSTRUCTION: 8 Marks. 30 Seconds Reading. 8 Minutes Writing.



Question 21 (8 marks)

The following electrochemical cell, with inert electrodes, has been constructed at 1000°C by Bobby, who wishes to verify Faraday's findings. The density of molten sodium is 0.75 g/mL .



- a. Write the overall equation occurring in this particular cell. (1 mark)

- b. The products of electrolysis are immediately removed so as to avoid them spontaneously reacting.

Calculate the amount of electrons, in mol , which must have passed through the cell if 200 mL of molten sodium was collected. (2 marks)

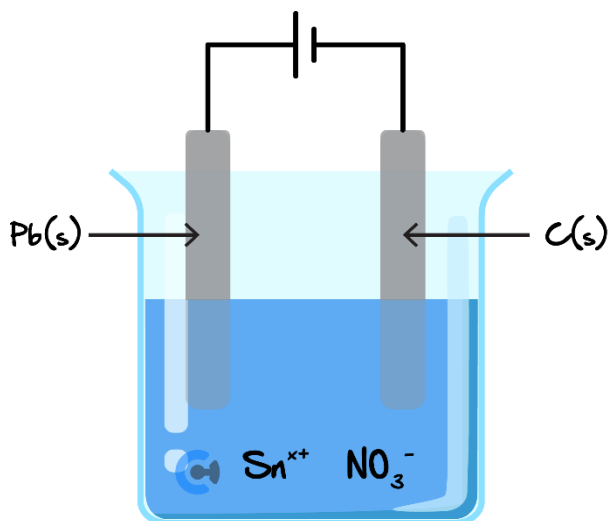
- c.**
- i.** Given that Bobby supplied a current of 30.0 A for 5.7 hours, calculate an experimental value of Faraday's constant, in C mol^{-1} . (2 marks)
-
-
-
-
- ii.** Calculate the elementary charge, e , of each individual electron, using the value for Faraday's constant derived in **part c. i.** (1 mark)
-
-
-
- d.** Propose **two** reasons as to why this cell is not used in industry to electroplate sodium metal onto objects. Justify your answer. (2 marks)
-
-
-
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Section I: Extension Questions (16 Marks)

Question 22 (6 marks)

Students are trying to determine the oxidation state of Tin in a solution of Tin nitrate:



- The graphite electrode was coated in 25 g of tin when 23.0 A were supplied for 36 minutes. Calculate the amount of electrons, in *mol*, flowing through the circuit. (1 mark)
- Given that the cell is only 80% efficient, calculate the theoretical amount of tin which **should** have deposited on the cathode, in *mol*, had the cell been 100% efficient. (2 marks)

- c. Hence or otherwise, calculate the charge on the Tin ion, and write the half-equation occurring at this electrode. (2 marks)

- d. Calculate the voltage supplied by the battery in order for this cell to operate. (1 mark)

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Question 23 (10 marks)

- a.** In the electrolysis of water with just enough voltage supplied (surplus of 0.01 V) a current of 5.2 A is passed through the system for one hour.

Calculate the mass of oxygen gas, in grams, evolved at the anode at SLC, assume 48% efficiency and 1.5 mg/L density. (4 marks)

- b.** Identify and explain which of Faraday's two laws of electrochemistry are involved in **part a.** (3 marks)

- c. It is known that another galvanic cell with HCl(aq) solution with platinum cathode and nickel anode with $\text{Ni(NO}_3)_2\text{(aq)}$ solution is connected in series with the cell supplying 5.2 A in **part a**.

Calculate the new energy required for the same volume of Oxygen gas produced at the same conditions (same efficiency). (3 marks)

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