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VCE Chemistry $\frac{3}{4}$
Introduction to Electrolysis [0.12]
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 (5 Marks)

Learning Objective: [2.1.1] - Identify differences between galvanic & electrolysis for electrodes, energy conversions, and electron flow



| | Galvanic Cells | Electrolytic Cells |
|---------------------------------------|-------------------------------|-------------------------------|
| Spontaneous Reaction | [Yes] / [No] | [Yes] / [No] |
| Energy Conversion | | |
| Type of Reaction | [Exothermic] / [Endothermic] | [Exothermic] / [Endothermic] |
| Oxidant / Reductant Relative Strength | | |
| Electron Flow | | |
| Anode | | |
| Cathode | | |
| Salt-Bridge / Electrolyte Ion Flow | Cations → [cathode] / [anode] | Cations → [cathode] / [anode] |

Learning Objective: [2.1.2] - Write equations & calculate EMF required for electrolytic reactions

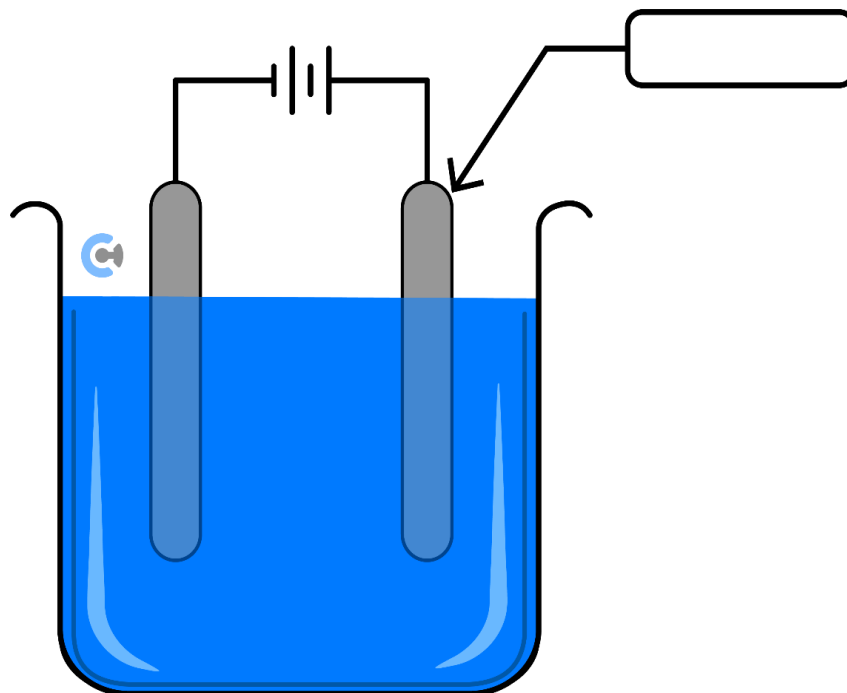


- When predicting electrolytic reactions, do not forget to include _____.
- Metals at the cathode are _____.
- Voltage required is _____.

Question 1 (5 marks) Walkthrough.

A cell involves the electrolysis of a solution of nickel (II) nitrate with a tin cathode and copper anode.

The diagram of the cell is shown below.



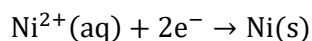
a. Label the right electrode as the cathode or anode in the diagram provided above. (1 mark)

b. Write the balanced half-equation for the reaction which occurs at the: (2 marks)

Positive electrode: _____

Negative electrode: _____

c. As the reaction progresses, multiple observations are seen to occur.



List **two** observations which occur in the electrolyte. Justify your answer. (2 marks)

Section B: Warm Up (12 Marks)

INSTRUCTION: 12 Marks. 8 Minutes Writing.



Question 2 (2 marks)

Complete the following table regarding the **type of reaction** occurring and the **polarity** for each electrode.

| | Galvanic Cells | Electrolytic Cells |
|---------|--|--|
| Anode | [reduction] / [oxidation] [positive] / [negative] | [reduction] / [oxidation] [positive] / [negative] |
| Cathode | [reduction] / [oxidation] [positive] / [negative] | [reduction] / [oxidation] [positive] / [negative] |

Question 3 (1 mark)

Which statement is true for both a galvanic cell and an electrolytic cell?

- A. Oxidation occurs at the negative electrode.
- B. The anode is negatively charged.
- C. The strongest oxidant will react with the weakest reductant.
- D. Electrons flow from the anode to the cathode.

Space for Personal Notes

Question 4 (1 mark)

Select the alternative that would only react in an electrolytic cell.

- A. $\text{Zn(s)} + \text{AgNO}_3\text{(aq)} \rightarrow \text{Zn(NO}_3)_2\text{(aq)} + \text{Ag(s)}$
- B. $\text{Mg(s)} + \text{H}_2\text{O(l)} \rightarrow \text{Mg(OH)}_2\text{(aq)} + \text{H}_2\text{(g)}$
- C. $2\text{H}_2\text{O(l)} \rightarrow 2\text{H}_2\text{(g)} + \text{O}_2\text{(g)}$
- D. $\text{Cl}_2\text{(g)} + \text{FeI}_2\text{(aq)} \rightarrow \text{FeCl}_2\text{(aq)} + \text{I}_2\text{(g)}$

Question 5 (1 mark)


Inspired from VCAA Chemistry Exam 2021

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2021/2021chem-w.pdf#page=4>

Consider the following characteristics of electrolytic cells and galvanic cells:

| Characteristic Number | Electrolytic Cells | Galvanic Cells |
|-----------------------|---------------------------------|----------------------------------|
| 1 | Cathode is negative. | Cathode is positive. |
| 2 | Have non-spontaneous reactions. | Have spontaneous reactions. |
| 3 | Reduction occurs at the anode. | Reduction occurs at the cathode. |
| 4 | Produce electricity. | Consume electricity. |

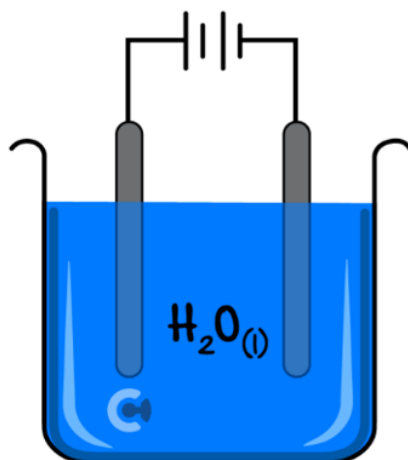
Which of the following combinations of characteristics of electrolytic cells and galvanic cells are correct?

- A. Only 1 and 2.
- B. Only 2 and 3.
- C. Only 3 and 4.
- D. Only 1, 2, and 4.

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Question 6 (7 marks)

Electricity is run through some water according to the following setup using inert electrodes.



a.

- i. State whether the left electrode is the anode or the cathode. (1 mark)

- ii. Hence, write the appropriate half-equation occurring at the positive electrode. (1 mark)

- b.** Write the other half-equation occurring in this cell. (1 mark)

- c.** Hence, list 3 things that would be observed as this cell operates. (3 marks)

1.

2.

3.

- d.** Find the voltage which needs to be inputted for the electrolytic cell to operate. (1 mark)

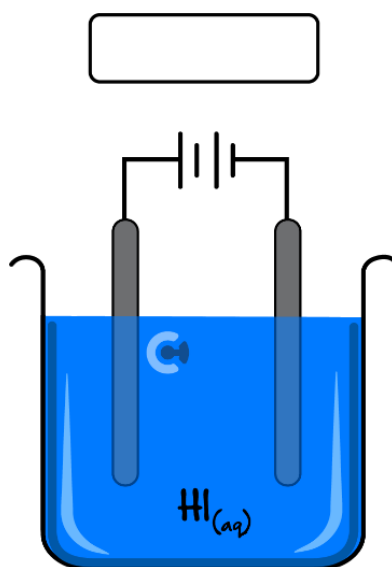
Section C: Ramping Up (14 Marks)

INSTRUCTION: 14 Marks. 11 Minutes Writing.



Question 7 (8 marks)

The following cell was set up by Athena using platinum electrodes. She inputs a voltage of 2 V.



a. Label the direction of electron flow by placing an arrow in the box above. (1 mark)

b. Write the relevant balanced anode half-equation occurring. (1 mark)

c. Write the balanced overall equation taking place in this cell. (1 mark)

- d. State the minimum voltage required to be inputted for the cell to operate. Hence, explain whether a reaction will occur, given Athena has inputted 2 V and state any other observations that would be made due to this. (2 marks)

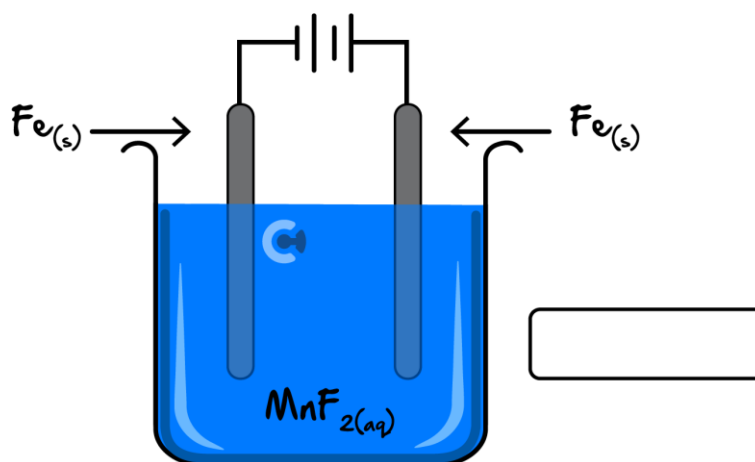
- e. Describe the colour change that would be observed within the electrolyte by Athena as this cell operates. Justify your answer. (1 mark)

- f. After some time, all the ions in the solutions are exhausted. Explain what would happen in the cell. (2 marks)

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Question 8 (6 marks)

Daniel has a few iron rods lying around so he decides to put them to use by constructing the following setup:



a. Label the electrode on the right as either the anode or cathode in the box provided. (1 mark)

b. Hence, write the relevant half-equation taking place at the right electrode. (1 mark)

c. Write the equation for the reaction taking place at the other iron electrode. (1 mark)

d.

i. Outline what colour the electrolyte is before any of the reactions take place. (1 mark)

ii. Using your answers from **part b.** and **part c.**, explain four different things that would be observed for this cell as it operates. (2 marks)

1.

2.

3.

4.

Section D: Getting Trickier I (10 Marks)

INSTRUCTION: 10 Marks. 8 Minutes Writing.



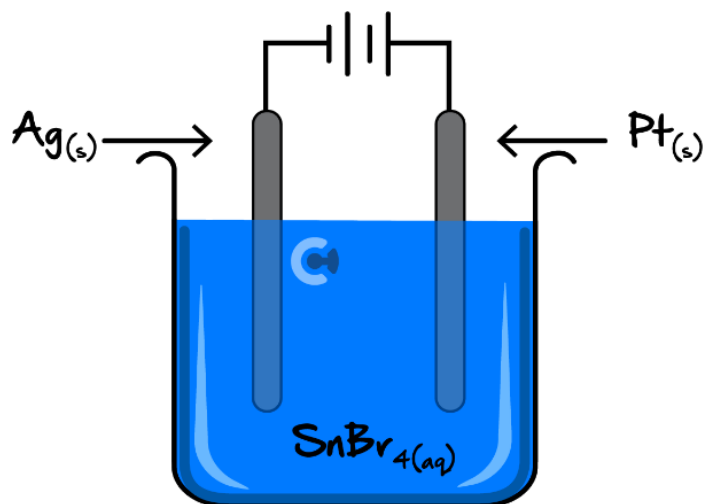
Question 9 (1 mark)

When 1 M CuSO_4 is electrolysed using a copper anode and platinum cathode, the products formed are:

- A. $\text{O}_2, \text{H}^+, \text{H}_2, \text{OH}^-$
- B. $\text{O}_2, \text{H}^+, \text{Cu}$
- C. $\text{Cu}^{2+}, \text{Cu}$
- D. $\text{Cu}^{2+}, \text{H}_2, \text{OH}^-$

Question 10 (9 marks)

Devon sets up the following cell with the intention of reacting to all of the silver.



- a. Explain, with appropriate justification, why the cell constructed will **not** achieve his goal. (2 marks)

- b.**
- i.** For the cell shown, write the appropriate half-equation which involves an increase in oxidation number for the species reacting. (1 mark)
- _____
- ii.** Write the other half-equation taking place. (1 mark)
- _____
- c.** State the one major change that would be observed by Devon as this cell operates. (1 mark)
- _____
- d.**
- i.** Propose what change Devon should make in order to realise his goal of using up the silver, using the same chemicals. (1 mark)
- _____
- ii.** Hence, with the change proposed in **part d.i.**, such that the silver is able to be consumed, state how the EMF supplied would differ from that in Devon's original set-up. (1 mark)
- _____
- _____
- _____
- iii.** State 2 other differences – in terms of physical observations – as this new cell operates, in comparison to the original cell shown. (2 marks)
- 1.** _____
- _____
- 2.** _____
- _____

Section E: Getting Trickier II (16 Marks)

INSTRUCTION: 16 Marks. 14 Minutes Writing.



Question 11 (9 marks)

Simran places solutions of potassium dichromate, hydrochloric acid, and sodium hydroxide together in a beaker.

- a. State what the strongest oxidant and the strongest reductant present are. (1 mark)

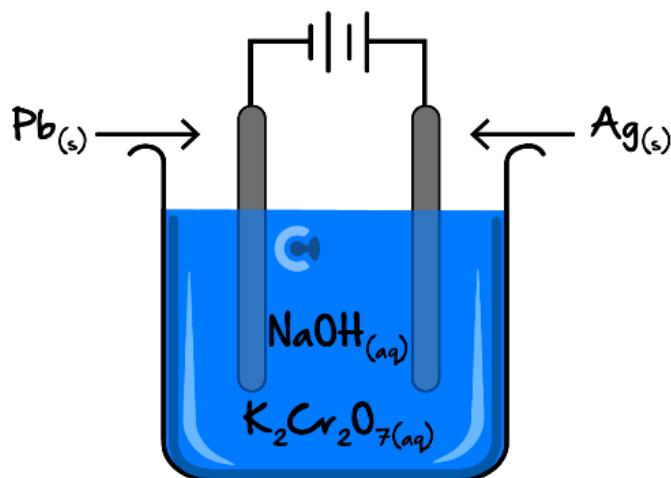
Strongest oxidant: _____

Strongest reductant: _____

- b. Explain whether she would observe a reaction upon mixing these chemicals together. If so, write the relevant overall equation taking place. (2 marks)

- c. As Simran's friend, you advised her that she should not have added hydrochloric acid to the beaker. Explain what effect this would have had on the scenario. (2 marks)

Following your advice, she finds a clean, new beaker and only adds in solutions of potassium dichromate and sodium hydroxide. She also adds in electrodes and connects the whole thing to a power supply, as shown below:



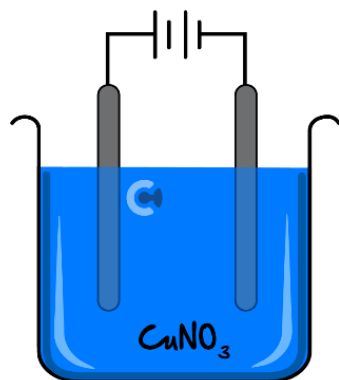
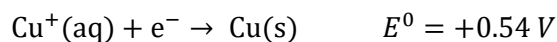
- d.
- Write the half-equation occurring at the negative electrode. (1 mark)
 - Write the other half-equation taking place. (1 mark)
 - Hence, or otherwise, if Simran were to place a pH meter in the electrolyte, outline what she would observe before she turns the power supply on, and when she turns it off at the conclusion of the experiment. (2 marks)

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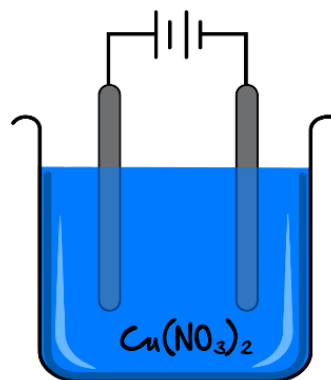
Question 12 (7 marks)

Leviana decides to set up an electrolytic cell *A* which comprises of a solution of both copper (I) nitrate, whereas Jody decides to set up an electrolytic cell *B* which comprises copper (II) nitrate. They both use platinum electrodes.

The half-equation for Cu^+ ions can be found below:



Cell A



Cell B

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

i. Cell A. (1 mark)

ii. Cell B. (1 mark)

b. As both cells react, different things are observed to happen in each cell in terms of colour change. Explain the difference in colour observed between the two cells. (2 marks)

- c. Both cells are run for 10.0 minutes at a voltage of 0.89 V and an electric current of 1.00 A. The mass of the electrodes from each cell weighs exactly 10.0 g.

When both the **electrodes** from each cell are weighed before and after electricity is run through the cell, it is found that one of the cells (Cell A or B) has much heavier electrodes than the other cell. State which cell is likely to have heavier electrodes, giving justification for your reasoning. (3 marks)

Let's take a BREAK!



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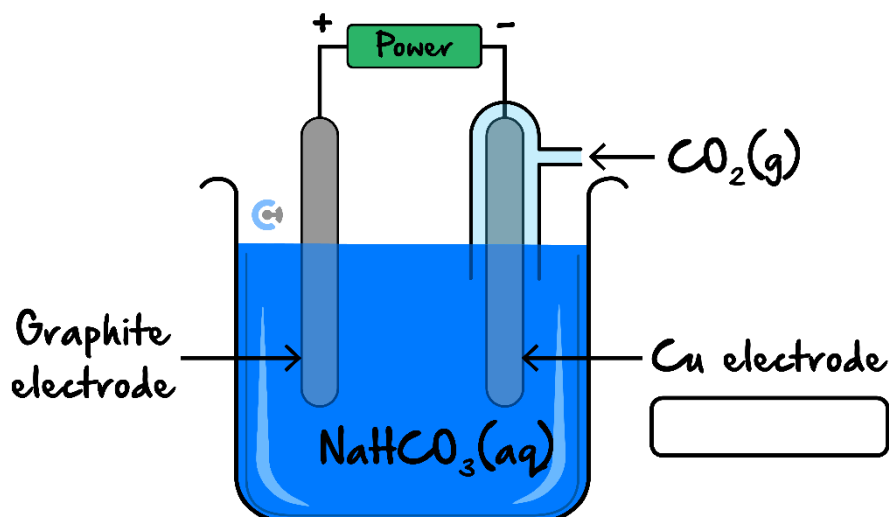
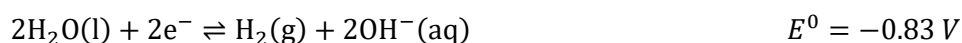
Section F: VCAA-Level Questions I (9 Marks)

INSTRUCTION: 9 Marks. 30 Seconds Reading. 9 Minutes Writing.



Question 13 (9 marks)

To produce ethanol, the electrolysis of carbon dioxide gas $\text{CO}_2(\text{g})$ in alkaline water is often used. The half-equation involving $\text{CO}_2(\text{g})$ and some other relevant species are as follows:



- a. Describe the requirements for an electrolytic cell to operate. (1 mark)

- b. Identify whether the Cu electrode is the anode or the cathode in the box above. (1 mark)

c. Write the balanced half-equation for the reaction occurring at:

i. The cathode. (1 mark)

ii. The anode. (1 mark)

d. Hence, determine the applied voltage required for the electrolysis of the cell to operate after some time has passed. (1 mark)

e. Describe the expected change in pH as the cell runs providing justification for your reasoning. (2 marks)

f. Identify the oxidising agent in this reaction. Give reasoning using oxidation numbers. (2 marks)

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Section G: Multiple Choice Questions (7 Marks)

INSTRUCTION: 7 Marks. 7 Minutes Writing.



Question 14 (1 mark)

Which one of the following pairs of statements is correct for both electrolysis cells and galvanic cells?

| | Electrolysis Cell | Galvanic Cell |
|----|---|--|
| A. | Both electrodes are always inert. | Both electrodes are always made of metal. |
| B. | Electrical energy is converted to chemical energy. | The voltage of the cell is independent of the concentration. |
| C. | Chemical energy is converted to electrical energy. | The products are dependent on the half-cell components. |
| D. | The products are dependent on the half-cell components. | Chemical energy is converted to electrical energy. |

Question 15 (1 mark)

When a direct current of electricity is conducted by an aqueous solution of an electrolyte in an electrolytic cell:

- A. The movement of electrons accounts for the current flow through the solution.
- B. The solution remains electrically neutral.
- C. Electrons always flow towards the positive electrode.
- D. The number of positive ions moving toward one electrode is always equal to the number of negative ions moving toward the other electrode.

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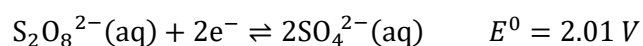
Question 16 (1 mark)

In the electrolysis of very dilute sodium chloride solution using platinum electrodes, a product at the anode is most likely to be:

- A. Chlorine.
- B. Oxygen.
- C. Sodium.
- D. Hydrogen.

Question 17 (1 mark)

A direct electric current is passed through 1.0 M K₂SO₄ solution using inert electrodes. The following standard reduction potential is provided in addition to those in the Data Book.



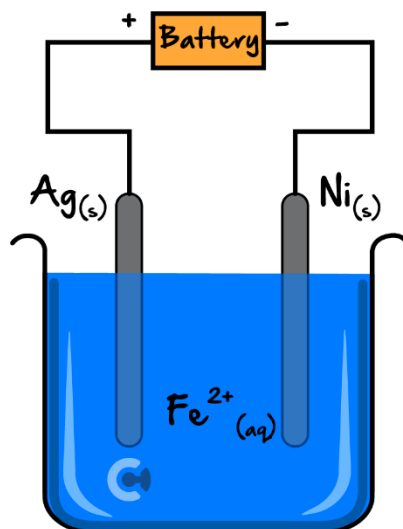
Which one of the following equations represents the reaction that occurs at the anode?

- A. $2\text{SO}_4^{2-}(\text{aq}) \rightarrow \text{S}_2\text{O}_8^{2-}(\text{aq}) + 2\text{e}^-$
- B. $2\text{H}_2\text{O}(\text{l}) \rightarrow \text{O}_2(\text{g}) + 4\text{H}^+ + 4\text{e}^-$
- C. $2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$
- D. $\text{K}^+(\text{aq}) + \text{e}^- \rightarrow \text{K}(\text{s})$

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Question 18 (1 mark)

Consider the following electrolytic cell.



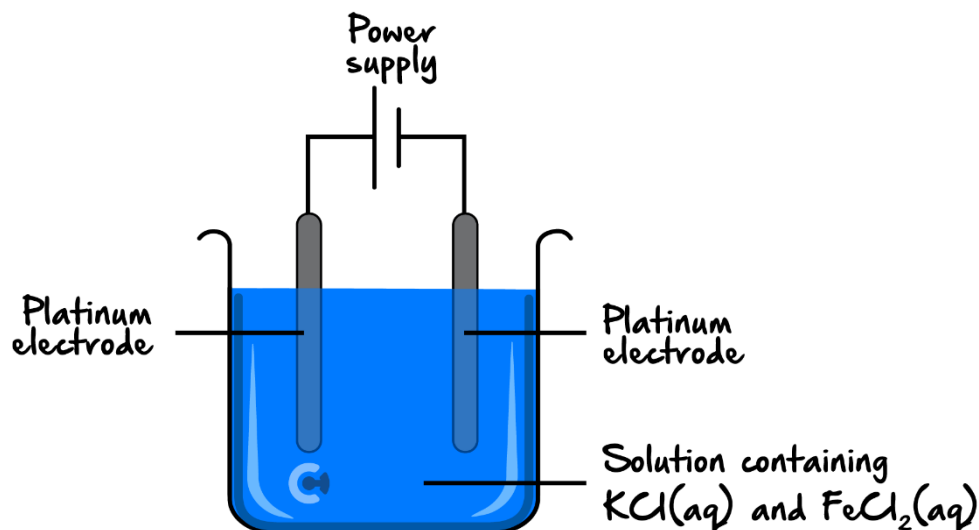
The reaction that occurs at the anode is:

- A. $\text{Fe}^{2+}(\text{aq}) + 2\text{e}^{-} \rightarrow \text{Fe}(\text{s})$
- B. $\text{Ag}^{+}(\text{aq}) + \text{e}^{-} \rightarrow \text{Ag}(\text{s})$
- C. $\text{Ni}(\text{s}) \rightarrow \text{Ni}^{2+}(\text{aq}) + 2\text{e}^{-}$
- D. $\text{Fe}^{2+}(\text{aq}) \rightarrow \text{Fe}^{3+}(\text{aq}) + \text{e}^{-}$

Space for Personal Notes

Question 19 (1 mark)

The diagram represents an arrangement used by a student to investigate the electrolysis of a mixture containing two metal chlorides. The solution contains 0.010 M KCl and 0.010 M FeCl_2 . The student carefully increased the voltage until the electrolysis began.



The product at the anode is most likely to be:

- A. Potassium metal.
- B. Iron(III) ions.
- C. Oxygen gas.
- D. Iron metal.

Question 20 (1 mark)

An electric current is passed through 1 M NaI solution. The pH in the container would:

- A. Increase at the anode and decrease at the cathode.
- B. Increase overall.
- C. Decrease overall.
- D. Increase at the cathode and decrease at the anode.

Space for Personal Notes

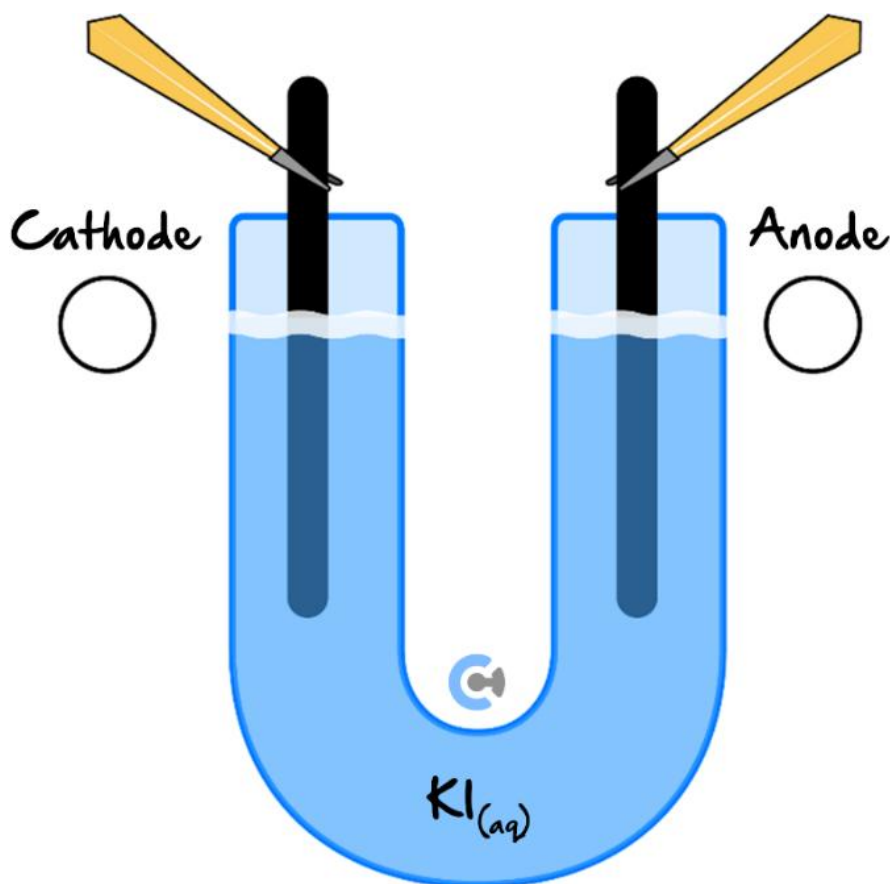
Section H: VCAA-Level Questions II (9 Marks)

INSTRUCTION: 9 Marks. 30 Seconds Reading. 9 Minutes Writing.



Question 21 (9 marks)

A solution of potassium iodide, KI(aq) is electrolysed using platinum electrodes according to the set-up below.



- a. Label the polarities of the electrodes in the boxes provided above. (1 mark)

b. As the reaction proceeds, a solid sludge is observed to be formed, from one electrode before sinking to the bottom of the electrolyte.

i. Identify the solid and the electrode where it is being formed providing justification for your reasoning. (3 marks)

ii. Explain why the solid does not coat onto the electrode, but rather, falls to the bottom of the electrolyte. (1 mark)

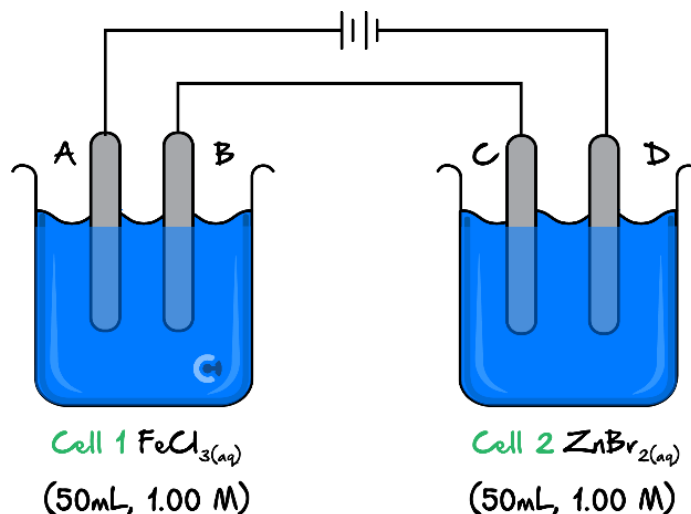
c. At the other electrode, bubbles are being formed and when a pH meter is inserted, its reading is not 7. Identify the gas formed and the corresponding pH change, writing a half-equation to justify your reasoning. (2 marks)

d. Describe what would happen if a match was held above the cell. Justify your reasoning, by writing an equation to show the reaction which would take place. (2 marks)

Section I: Extension Questions (5 Marks)

Question 22 (5 marks)

Two electrolytic cells were connected in series using platinum electrodes, as shown below:



- a. Predict the reactions occurring at:

Electrode A: _____ (1 mark)

Electrode D: _____ (1 mark)

- b. Write an overall equation for Cell 1. (1 mark)

- c. Determine the voltage that would be required for the electrolysis of the two solutions. Using equations if appropriate, describe the effect, if any, that this voltage will have on the predicted reactions occurring at electrodes A to D. (2 marks)

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VCE Chemistry $\frac{3}{4}$

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