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VCE Chemistry ¾
AOS 2 Revision I [2.5]
Contour Check

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Section A: [2.1] – Introduction to Electrolysis (Checkpoints) (27 Marks)

Sub-Section [2.1.1]: Identify Differences between Galvanic & Electrolysis for Electrodes, Energy Conversions, Electron Flow

Question 1 (3 marks)

a. Which of the following statements about electrolytic cells is correct? (1 mark)

A. Electrolytic cells undergo exothermic reactions that result in a lower enthalpy of products than reactants.

B. Electrolytic cells are expensive to produce due to their requirement for Pt(s) catalysts.

C. Electrolytic cells have the weakest oxidant and weakest reductant react together.

D. Electrolytic cells are an example of non-spontaneous reactions that produce chemical energy.

b. Determine the **false** statement regarding the properties of galvanic and electrolytic cells. (1 mark)

A. Reduction in galvanic and electrolytic cells occurs at the cathode.

B. Electrons flow from cathode to anode in an electrolytic cell.

C. Galvanic cells convert chemical energy to electrical energy whilst electrolytic cells convert electrical energy to chemical energy.

D. The cathode is positively charged in a galvanic cell.

c. The cathode of an electrolytic cell: (1 mark)

A. Has a positive polarity and reduction occurs.

B. Has a positive polarity and oxidation occurs.

C. Has a negative polarity and reduction occurs.

D. Has a negative polarity and oxidation occurs.

Space for Personal Notes

Question 2 (2 marks)

Betty has set up a cell at school which requires electrical input to operate.

a. State the energy conversion occurring in the cell. (1 mark)

_____

b. Hence, determine whether electrolysis is exothermic or endothermic (1 mark)

_____

Space for Personal Notes

Question 3 (2 marks)

a. Select the option which accurately describes the electron flow of galvanic and electrolytic cells. (1 mark)

A.

Cell type	Electron flow
Galvanic	Positively to negatively charged electrode.
Electrolytic	Positively to negatively charged electrode.

B.

Cell type	Electron flow
Galvanic	Positively to negatively charged electrode.
Electrolytic	Negatively to negatively charged electrode.

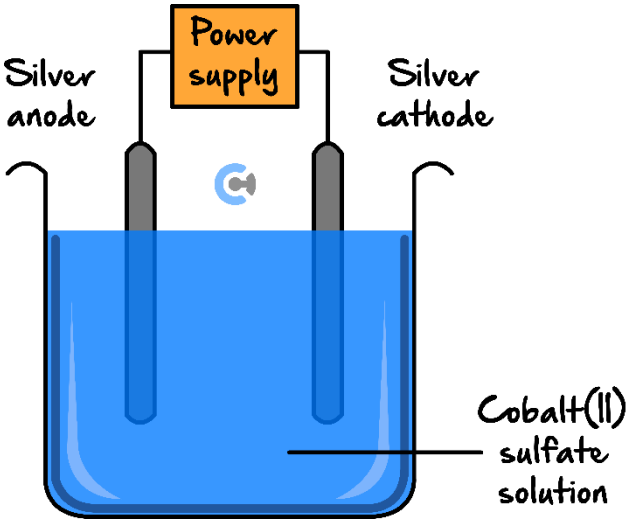
C.

Cell type	Electron flow
Galvanic	Negatively to positively charged electrode.
Electrolytic	Positively to negatively charged electrode.

D.

Cell type	Electron flow
Galvanic	Negatively to positively charged electrode.
Electrolytic	Negatively to positively charged electrode.

b. Katie is analysing the electrolytic cell shown below:



Determine the purpose of the Cobalt (II) sulphate solution. (1 mark)

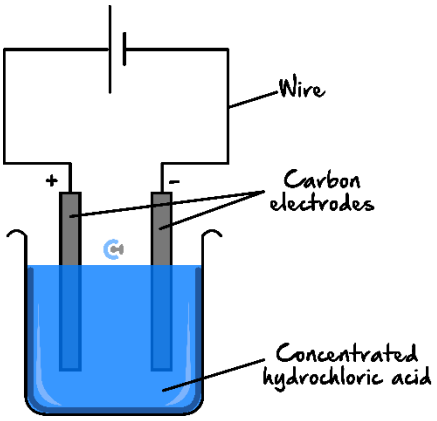
_____

Space for Personal Notes

Sub-Section [2.1.2]: Write Equations & Calculate EMF Required for Electrolytic Reactions

Question 4 (9 marks)

a. Michelle is electrolysing 3.0 *M* of HCl in the cell shown below.



i. Write the equation which occurs at the cathode. (1 mark)

_____

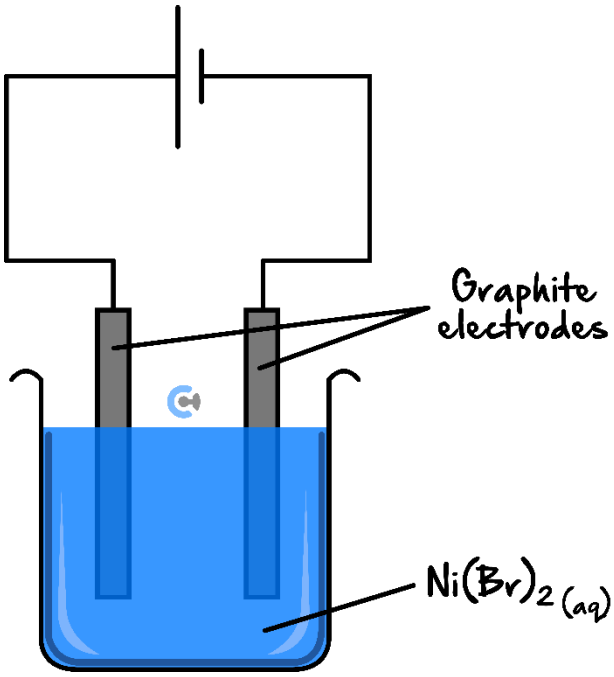
ii. Write the equation which occurs at the anode. (1 mark)

_____

iii. Hence, write the overall equation for the cell. (1 mark)

_____

b. Dai is operating a cell containing 1.0 *M* of nickel (II) bromide, shown below.



i. Write the equation which occurs at the cathode. (1 mark)

_____

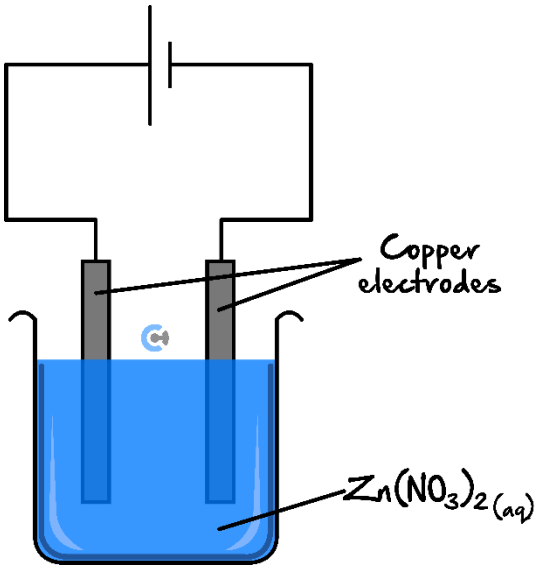
ii. Write the equation which occurs at the anode. (1 mark)

_____

iii. Hence, write the overall equation for the cell. (1 mark)

_____

c. Henry is operating a cell containing 1.0 *M* of zinc nitrate. The cell is shown below.



i. Write the equation which occurs at the cathode. (1 mark)

_____

ii. Write the equation which occurs at the anode. (1 mark)

_____

iii. Hence, write the overall equation for the cell. (1 mark)

_____

Space for Personal Notes

Question 5 (5 marks)

a. Draw a labelled cell for the electrolysis of $CdSO_4(aq)$ with a lead cathode and platinum anode. (2 marks)

b. Write the balanced half-equations occurring at the:

i. Anode. (0.5 marks)

_____

ii. Cathode. (0.5 marks)

_____

c. List any observations made at either electrode. (2 marks)

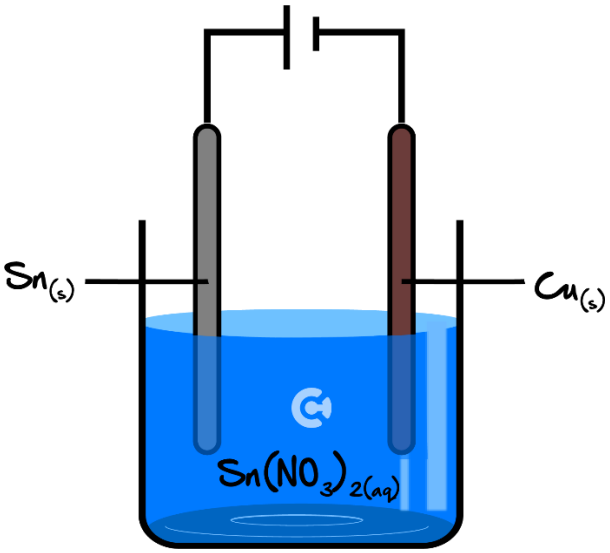
_____

_____

_____

Question 6 (3 marks)

A solution of Tin (II) nitrate is being electrolysed in an electrolytic cell containing a copper cathode and tin anode. A diagram of the electrolytic cell is shown in the diagram below.



a. Write the balanced half-equations occurring at the:

i. Anode. (0.5 marks)

_____

ii. Cathode. (0.5 marks)

_____

b. The cell is able to be ran for 30 minutes under standard conditions. When a separator membrane was added that prevented the flow of ions, the cell was only able to be run for 5 minutes. Explain what the separator membrane did to limit the run time of the cell. (2 marks)

_____

_____

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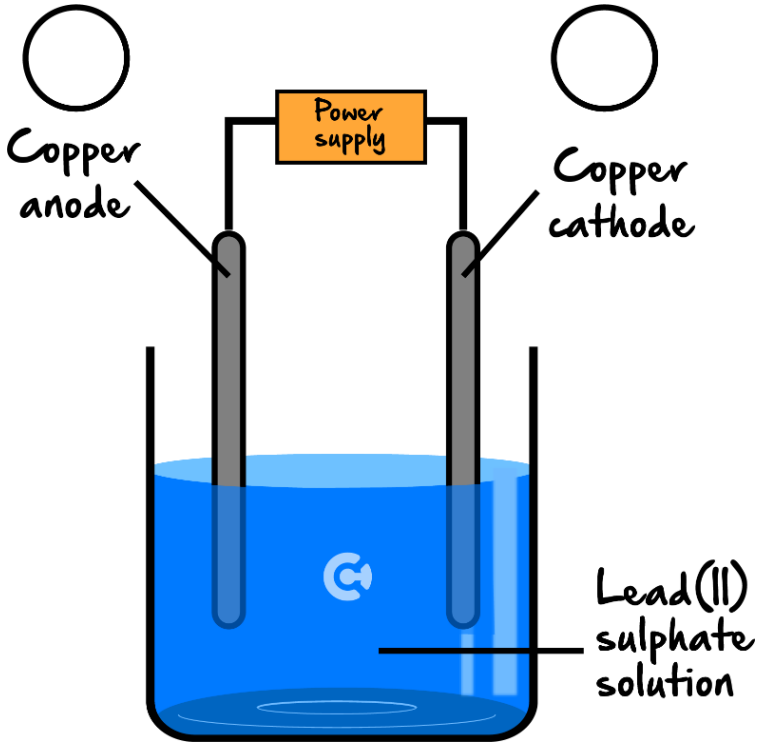
Space for Personal Notes

Question 7 (3 marks)

The electrolysis of 1 *M* solution of Lead (II) sulphate ($PbSO_4$) is undertaken with copper electrodes at 25°C. A diagram of this electrolytic process is shown in the following diagram below.



a. Label the polarity of each electrode in the diagram above. (1 mark)

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

i. Cathode. (0.5 marks)

_____

ii. Anode. (0.5 marks)

_____

c. List any observations seen at either electrode. (1 mark)

_____

_____

_____

Section B: [2.2] – Features of Electrolytic Cells (Checkpoints) (47 Marks)

Sub-Section [2.2.1]: Find Electrolytic Reactions in Non-Standard Conditions (Molten & High Concentration)

Question 8 (3 marks)

A solution of magnesium bromide is being electrolysed using a copper cathode and carbon anode at molten conditions.

a. Write a balanced half-equation (including states) for the reaction occurring at the:

i. Anode. (1 mark)

_____

ii. Cathode. (1 mark)

_____

b. State the voltage required for this cell to operate. (1 mark)

_____

Space for Personal Notes

Question 9 (4 marks)

Molten aluminium nitrate is being electrolysed using a nickel cathode and iron anode.

a. Write the balanced half-equation occurring at the:

i. Negative electrode. (1 mark)

_____

ii. Positive electrode. (1 mark)

_____

b. If we changed the nickel cathode into a zinc cathode, state any changes that might occur to the reaction. (2 marks)

_____

_____

_____

Space for Personal Notes

Question 10 (2 marks)

An electrolytic cell is set up using inert electrodes inside a 1.0 *M* solution of NaCl. A diagram of the shell is shown below.

a. Over the progression of the reaction:

A. Bubbles will be served at both electrodes.

B. Sodium metal will begin to plate the cathode and chlorine gas at the anode.

C. Sodium ions will be produced at the positive electrode and chlorine gas will be produced at the cathode.

D. Bubbles will only appear at one of the electrodes.

b. The concentration of NaCl is then increased to 5.0 *M*. The reaction at the negative electrode will now be:

A. $Na^+(aq) + e^- \rightarrow Na(s)$

B. $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

C. $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

D. $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

Space for Personal Notes

Question 11 (6 marks)

A molten cell is set up containing a solution of potassium sulphate and is mixed with a solution of lithium fluoride. The electrolytic cell is then set up using a graphite cathode and lead anode.

a. Write the half-equation occurring at the:

i. Anode. (1 mark)

_____

ii. Cathode. (1 mark)

_____

b. Explain an observation that takes over the course of the reaction. (2 marks)

_____

_____

c. Suggest an improvement to this cell which would allow it to be operational over a longer period of time. (2 marks)

_____

_____

_____

Space for Personal Notes

Sub-Section [2.2.2]: Identify Features of Electrolytic Cells & Their Purpose

Question 12 (2 marks)

a. Which of the following is an advantage of using a molten electrolyte in an electrolytic cell?

A. Molten electrolytes reduce the melting point of the electrodes.

B. Molten electrolytes decrease the conductivity of the cell.

C. Molten electrolytes allow for the electrolysis of compounds that are insoluble.

D. Molten electrolytes prevent any ion movement.

b. Why might an electrolytic cell use a lead anode in the electrolysis of a fluoride salt?

A. Lead reacts vigorously with fluorine gas, enhancing the reaction.

B. Lead is a poor conductor of electricity.

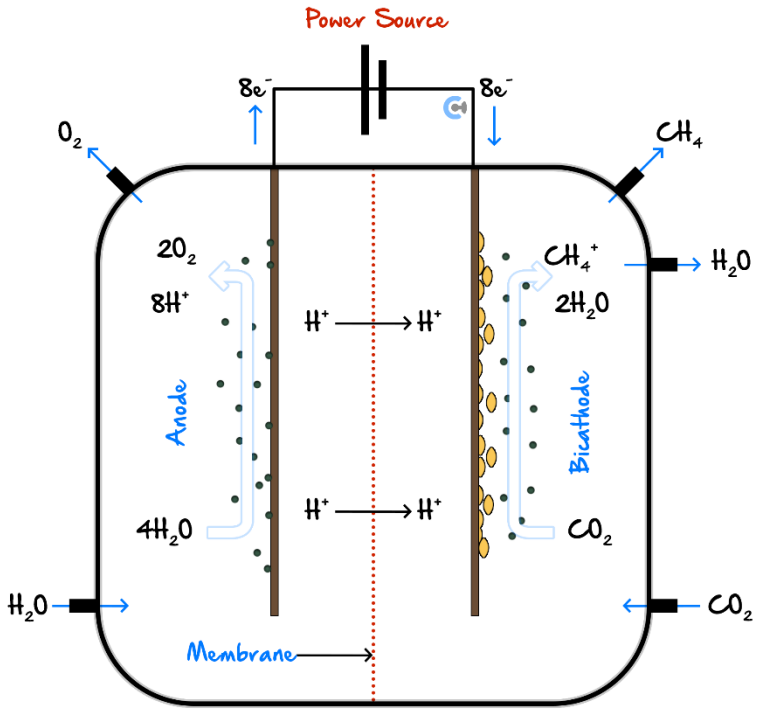
C. Lead is resistant to oxidation and minimises anode degradation.

D. Lead actively releases oxygen gas when in contact with fluoride ions.

Space for Personal Notes

Question 13 (3 marks)

Electromethanogenesis cells use bacteria and organic matter to turn CO_2 back into CH_4 (biogas) as a form of renewable energy production. A diagram is shown below.



a. What is the reaction that occurs at the anode? (1 mark)

_____

b. Biogas is the primary product, is it renewable? Explain. (2 marks)

_____

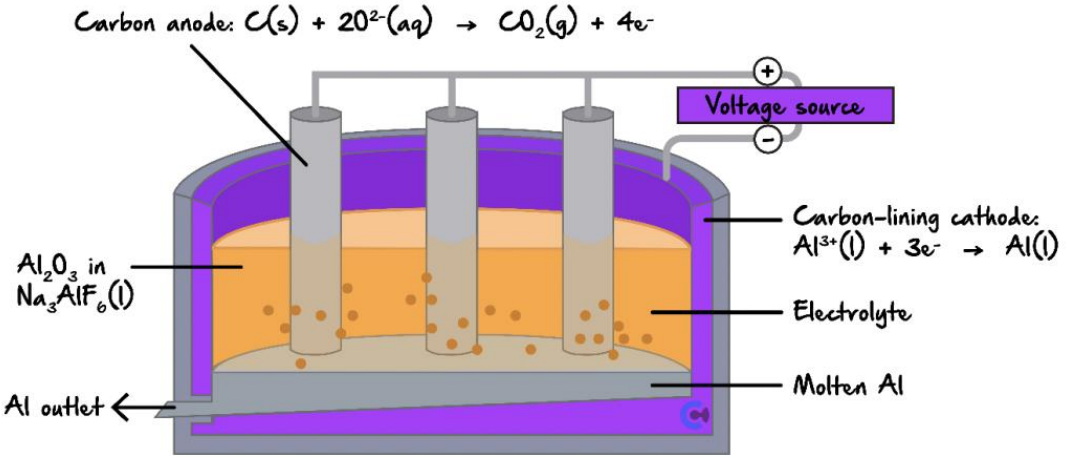
_____

_____

Space for Personal Notes

Question 14 (5 marks)

Consider the following Hall-Heroult cell.



a. If the cell is typically enclosed, explain why it is necessary to include a gas pump that is separate from the Al outlet. (2 marks)

_____

_____

_____

b. If the aluminium oxide was dissolved in a solution of water, what would occur to the aluminium being produced? (2 marks)

_____

_____

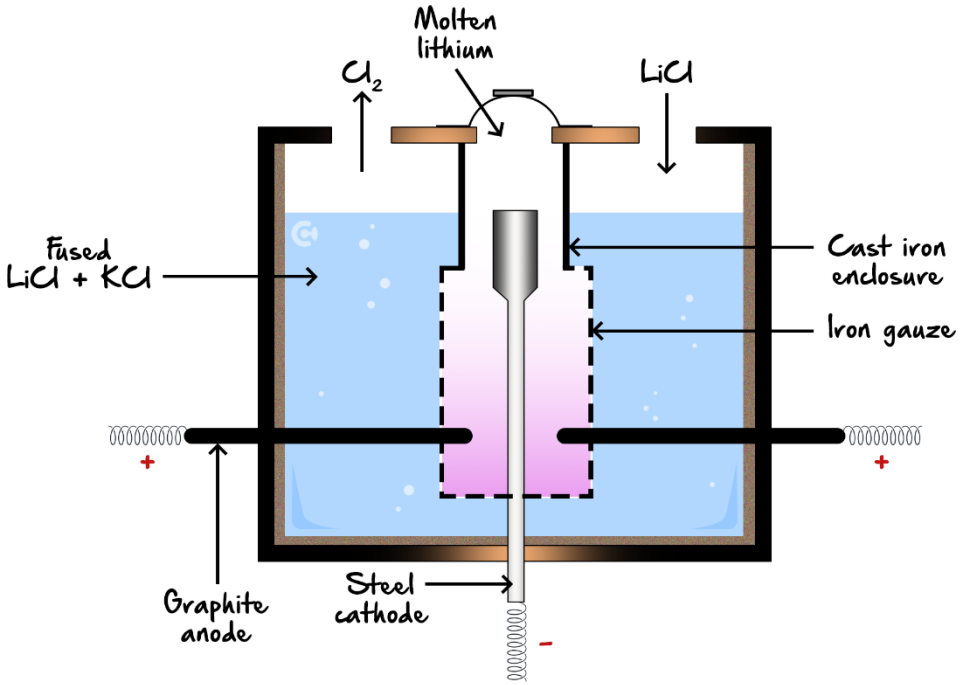
c. What is the overall reaction occurring in the cell? (1 mark)

_____

Space for Personal Notes

Question 15 (7 marks)

Lithium, an alkali metal exhibits a diverse array of scientific applications, which is increasingly important in today's digital society. The below is an example of an industrial cell that uses lithium.



a. Write the reaction occurring at the:

i. Anode. (1 mark)

_____

ii. Cathode. (1 mark)

_____

b.

i. By using molten conditions, the cell operates much more safely than under standard conditions. Explain how this is possible. (2 marks)

_____

_____

_____

ii. Is the production of pure lithium possible under standard conditions? (1 mark)

_____

_____

c. An iron gauze is placed around the cathode, explain its purpose. (2 marks)

_____

_____

_____

Space for Personal Notes

Sub-Section [2.2.3]: Identify Key Features, Write Reactions & Relate to Sustainability & Green Chemistry Principles Regarding Production of Green Hydrogen (PEM & Artificial Photosynthesis)

Question 16 (2 marks)

What is a key challenge with the practical usage of artificial photosynthesis, with regards to the product created?

_____

_____

_____

Question 17 (3 marks)

The PEM electrolyser is an innovative method of producing hydrogen gas.

a. Write its half-equations for the reactions at both the cathode and anode. (2 marks)

_____

_____

b. The setup of a PEM electrolyser is very specific. Describe the qualities of a typical electrode you might find in one of these cells. (1 mark)

_____

_____

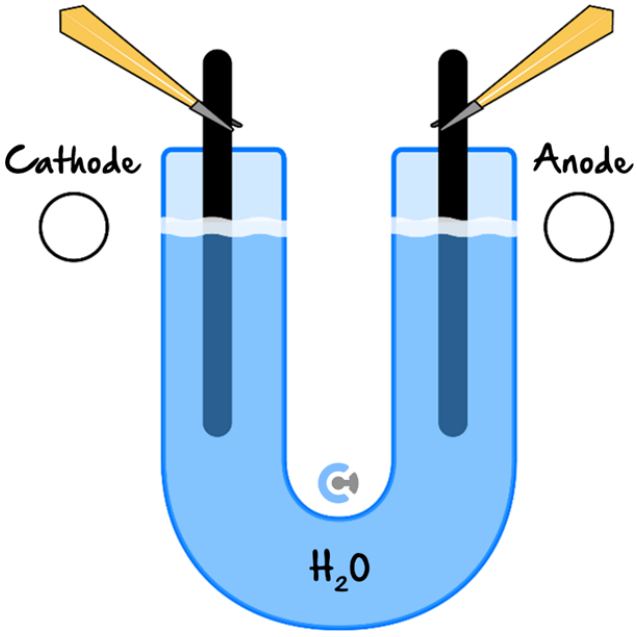
Space for Personal Notes

Question 18 (3 marks)

Explain the environmental advantages that you would get if you preferred to use artificial photosynthesis over a PEM electrolyser to produce hydrogen gas.

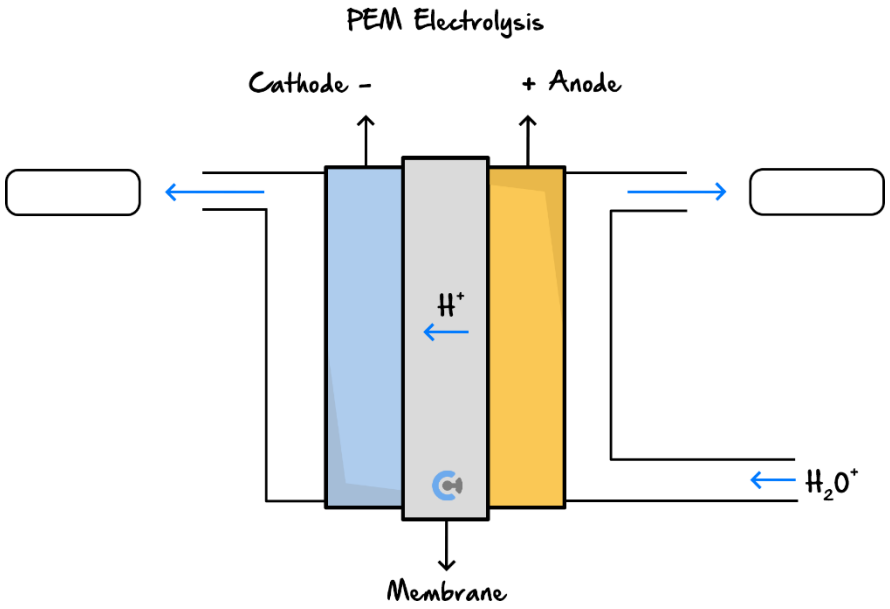
Question 19 (7 marks)

Hydrogen production can be done through two primary ways, electrolysis and steam reforming. An example of an electrolytic cell producing hydrogen gas is shown below.



a. This cell does not produce 'green' hydrogen. Explain why. (2 marks)

Polymer electrolyte membrane electrolysers (PEMs) are a method of producing green hydrogen gas.



b. On the diagram above, label the products at the anode and cathode in the boxes provided. (1 mark)

c.

i. Explain how hydrogen gas produced through PEM electrolysis can be considered 'green' whereas, that from simple electrolysis cannot. (2 marks)

_____

_____

_____

ii. Hence or otherwise, comment on the sustainability of the PEM electrolyser ensuring that you reference green chemistry principles and sustainable development goals. (2 marks)

_____

_____

_____

Space for Personal Notes

Section C: [2.3] – Secondary Cells & Connected Cells (Checkpoints) (46 Marks)

Sub-Section [2.3.1]: Write Discharge & Recharge Reactions in Secondary Cells & Redox Flow Batteries

Question 20 (2 marks)

a. Zinc-bromine rechargeable batteries are commonly used within electric vehicles for efficient and quick releases of large amounts of energy.

The reaction occurring in a zinc-bromine cell during discharge is shown below.

$$Zn(s) + Br_2(l) \rightarrow ZnBr_2(s)$$

An observation noted during recharge will be: (1 mark)

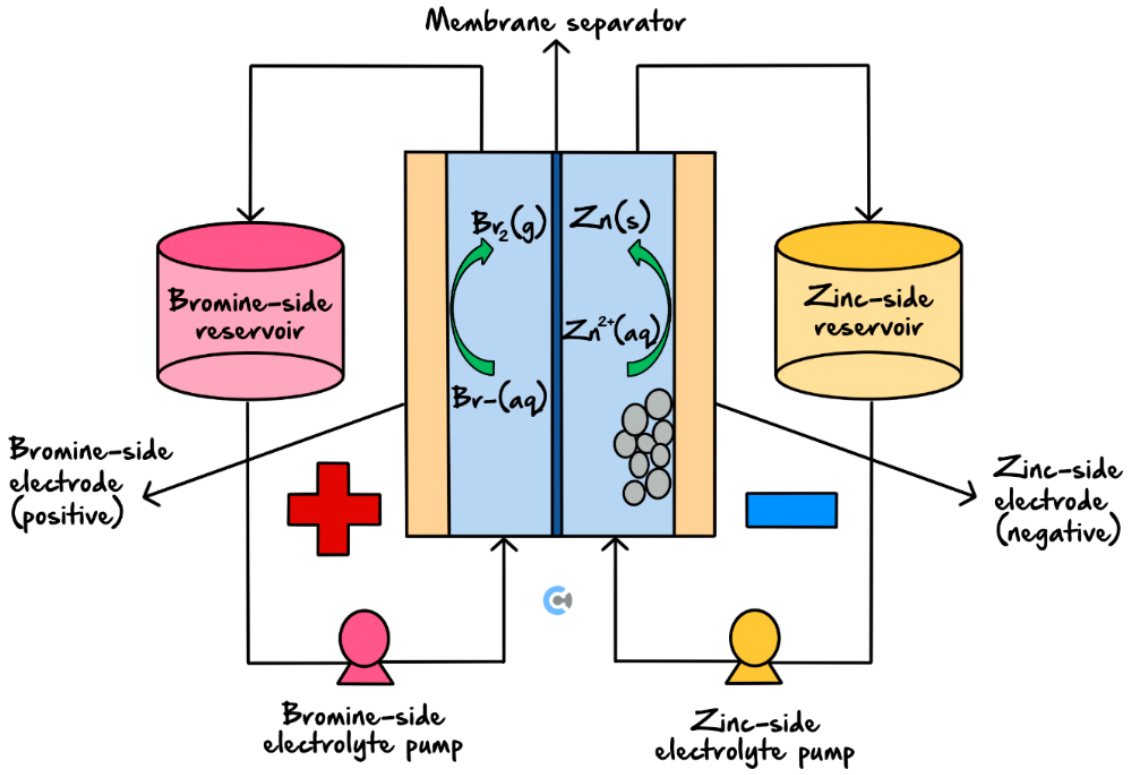
A. Decrease in mass of the cathode.

B. Increase in intensity of brown in the electrolyte.

C. Release of thermal energy.

D. A voltage produced of $+1.85\ V$.

b. An image of a zinc-bromine redox flow battery is shown below.



It can both discharge and recharge. The reactions that occur within the cell are shown below:

$$Br_2(l) + 2e^- \leftrightharpoons 2Br^-(aq) \qquad E^0 = +1.09\,V$$

$$Zn^{2+}(aq) + 2e^- \leftrightharpoons Zn(s) \qquad E^0 = -0.76\,V$$

An observation that would be made during the recharge of the cell would be: (1 mark)

A. Increase in mass at the bromine-side reservoir.

B. Decrease in mass at the zinc-side reservoir.

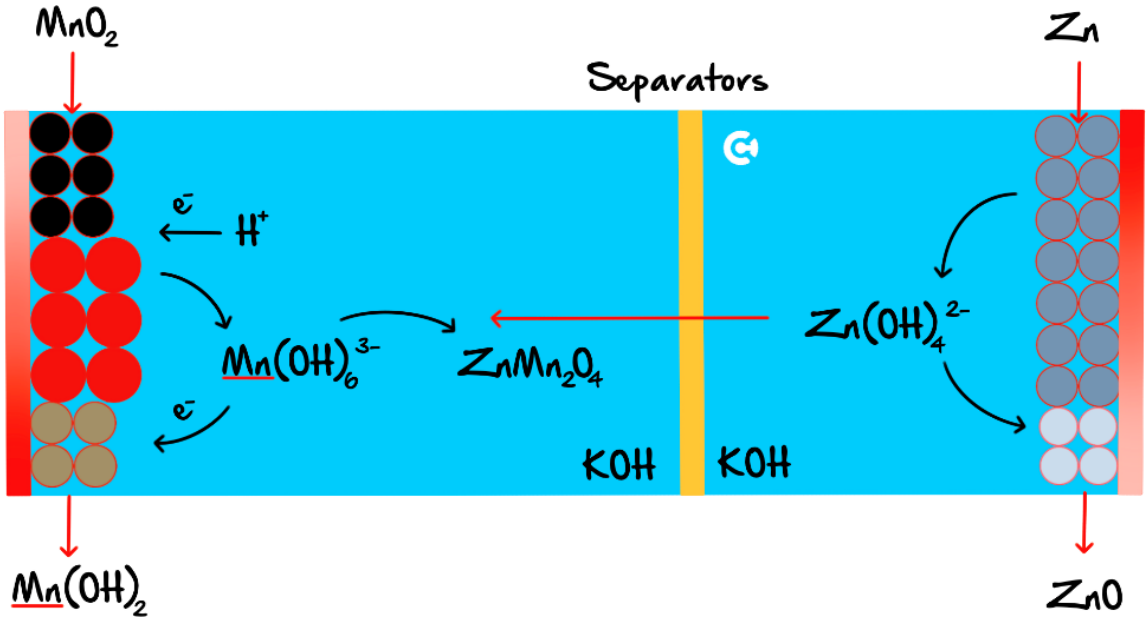
C. Brown bromine liquid being produced at the anode.

D. Zinc solid being produced at the anode.

Space for Personal Notes

Question 21 (4 marks)

A manganese dioxide zinc half-cell is shown below. It uses multi-step reactions to both recharge and discharge.



The overall reaction occurring during discharge is shown below:

$$MnO_2(s) + Zn(s) + H_2O(l) \rightarrow ZnO(s) + Mn(OH)_2$$

a. Write the balanced equation for the reaction that occurs at the anode during discharge. (1 mark)

_____

_____

b. Write the balanced equation for the oxidation reaction occurring during recharge. (1 mark)

_____

_____

c. Explain the purpose of the separator in this secondary cell. (2 marks)

_____

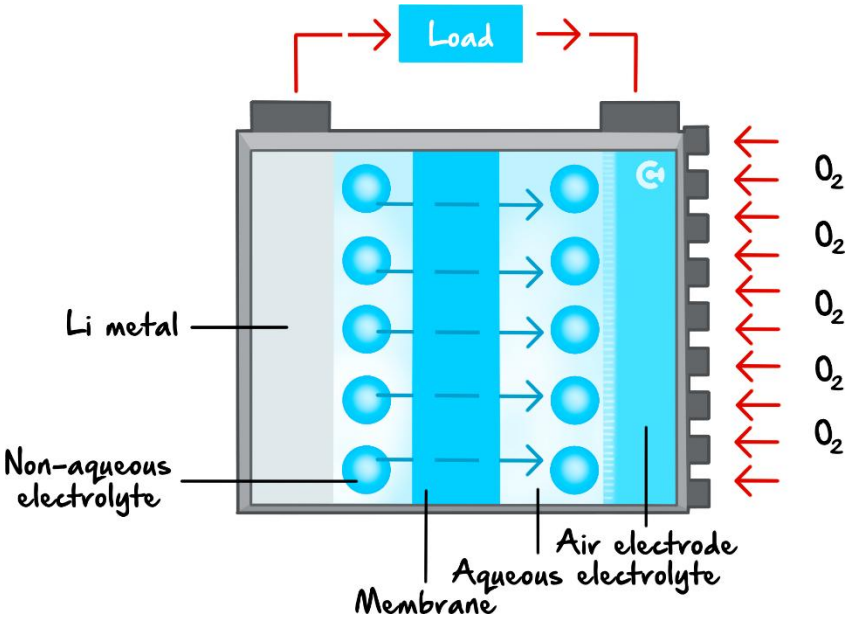
_____

_____

Question 22 (6 marks)

Lithium-air batteries, celebrated for their promising high energy density, hold potential as next-generation power sources in various applications.

A diagram of a lithium-air battery is shown below.



The following reaction occurs in an acidic electrolyte whilst the cell is undergoing discharge:

$$4Li(s) + O_2(g) + 4H^+(aq) \rightarrow 4Li^+(aq) + 2H_2O(l)$$

a.

i. Write the reaction occurring at the cathode as the cell is producing energy. (1 mark)

_____

ii. Hence or otherwise, identify the conjugate oxidant of the discharge reaction. (1 mark)

_____

b. Determine the voltage that must be inputted in order for the cell to be recharged. (1 mark)

_____

c. A non-aqueous electrolyte is used within some part of the cell. Explain a potential hazard in using an aqueous electrolyte throughout the entire cell. (3 marks)

_____

_____

_____

_____

Space for Personal Notes

Sub-Section [2.3.2]: Identify Factors Which Affect Rechargeability & Compare Similarities/Differences between Secondary Cells and Other Cells

Question 23 (1 mark)

Secondary cells are used in phone batteries due to their rechargability. Which of the following is a unique feature about the reactions in secondary cells?

A. The reactions both require the input of electrical energy in order to operate.

B. The products of discharge remain in contact with the electrodes.

C. The electrodes are inert and allow for theoretically indefinite rechargeability.

D. The discharge reactions of the cathode will occur at the other electrode during recharge.

Question 24 (2 marks)

a. Which of the following statements about secondary cells is correct? (1 mark)

A. Secondary cells can force electrons to travel against natural electrostatic forces to make the cathode negative.

B. Secondary cells minimise side reactions by always having a membrane between electrodes.

C. Secondary cells typically operate using porous electrodes in order to increase the surface area and increase the rate of reaction.

D. Secondary cells allow electrons to always follow natural electrostatic forces.

b. Which of the following statements accurately describes a feature of secondary cells? (1 mark)

A. Exhibit minimal self-discharge rates compared to primary cells.

B. Predominantly used in low-drain devices due to their limited capacity.

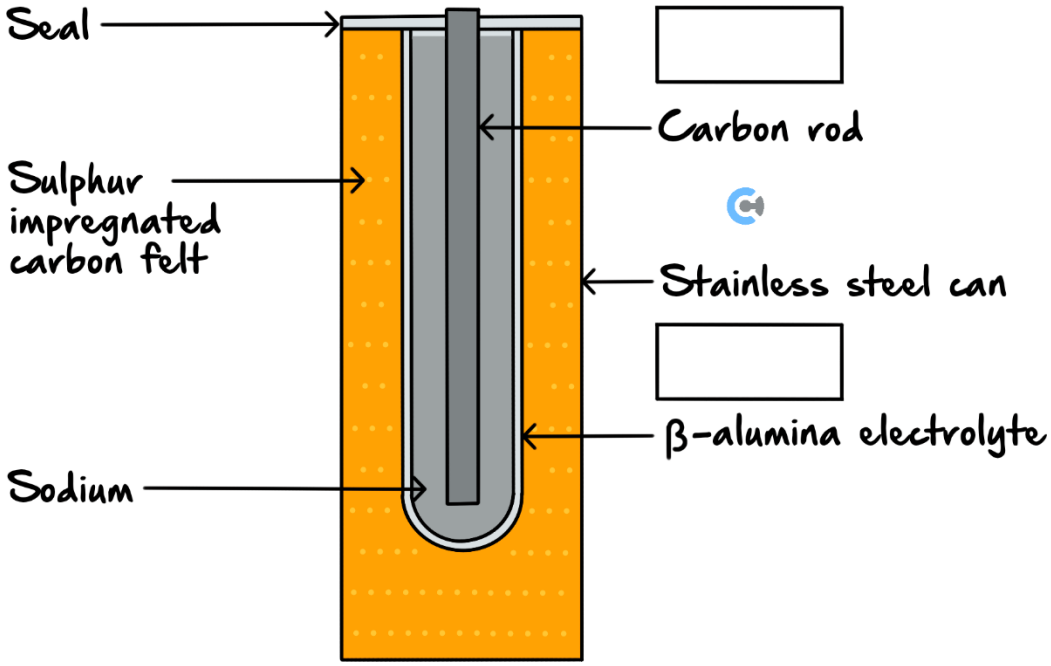
C. Rely on non-reversible chemical reactions for energy conversion.

D. Typically operate optimally in extreme temperature conditions due to their robust design.

Space for Personal Notes

Question 25 (6 marks)

Sodium-sulphur batteries are used for large-scale energy production and storage due to their high energy density and long life cycle. This allows them to have applications in storing renewably generated energy from sources such as wind and solar. It utilised molten sodium and sulphur, with a solid β-alumina electrolyte. A diagram of a sodium-sulphur cell is shown below.



The overall reaction occurring within the cell during discharge is:

$$Na(l) + S(l) \rightarrow Na_2S(l)$$

a. In the boxes provided above, label the location of the anode and cathode during discharge. (1 mark)

b. Write the reaction for the reaction occurring at the positive electrode as energy is being produced. (1 mark)

_____

c.

i. β-alumina is added to the electrolyte for proper operation of the cell, it can be collected and reused after the reaction has been completed. Explain the role of the β-alumina within the cell. (2 marks)

_____

_____

_____

ii. There is a separator between either of the electrodes that allows for the flow of $Na^+(aq)$ ions. Explain two purposes for Na^+ions within the cell. (2 marks)

_____

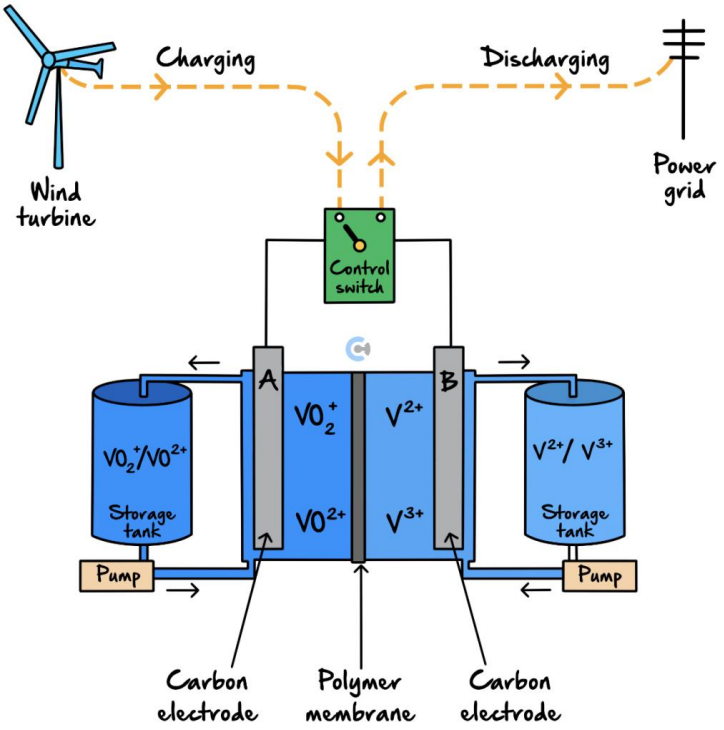
_____

_____

Space for Personal Notes

Question 26 (9 marks)

Vanadium redox flow batteries can be used as a means of adding energy generated by solar or wind energy to the power grid. An example of a typical vanadium redox flow battery is shown below.



a.

i. Given that electrode *B* is negative during discharge, state the reaction occurring at electrode *A* during recharge. (2 marks)

_____

_____

_____

ii. Hence or otherwise, explain why a polymer membrane must be added to the cell using relevant half-equations to support your response. (2 marks)

_____

_____

_____

_____

b. Explain how the control switch will allow for non-spontaneous reactions to occur when taking energy from the wind turbine. (3 marks)

_____

_____

_____

_____

_____

c. It can be claimed that the cell could be considered a fuel cell. Comment on the accuracy of this claim. (2 marks)

_____

_____

_____

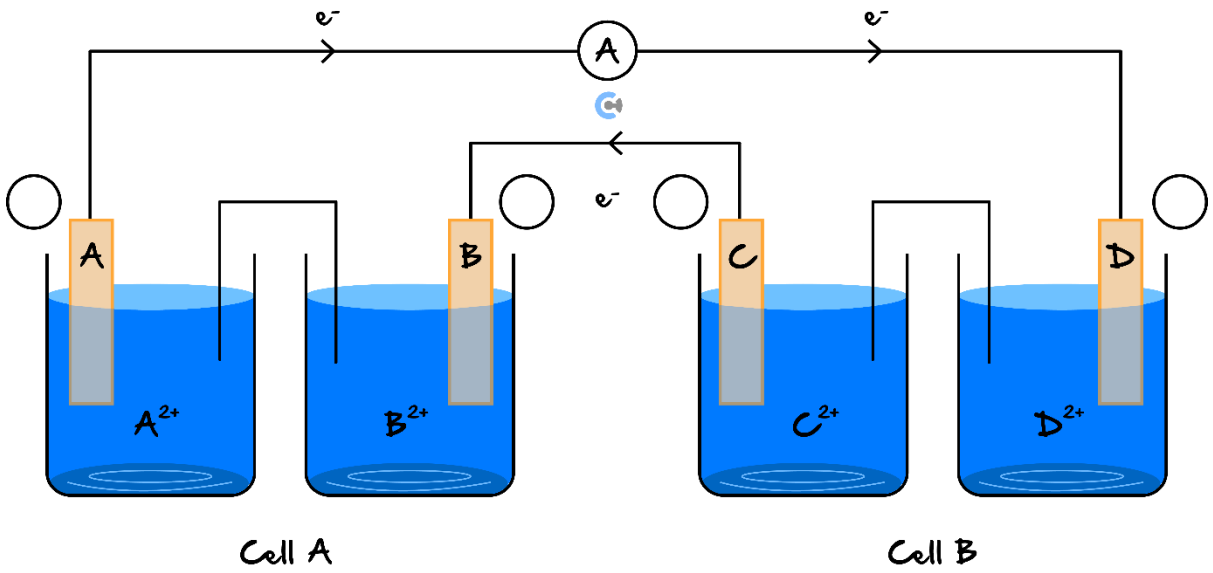
_____

Space for Personal Notes

Sub-Section [2.3.3]: Find Reactions Occurring in Connected Cells

Question 27 (3 marks)

Two galvanic cells are connected together, as shown in the diagram.



a. Label the polarities of each electrode in the box provided above. (1 mark)

b. Write the half-equation which occurs at the following electrodes. States are not required.

i. Electrode *A*. (1 mark)

_____

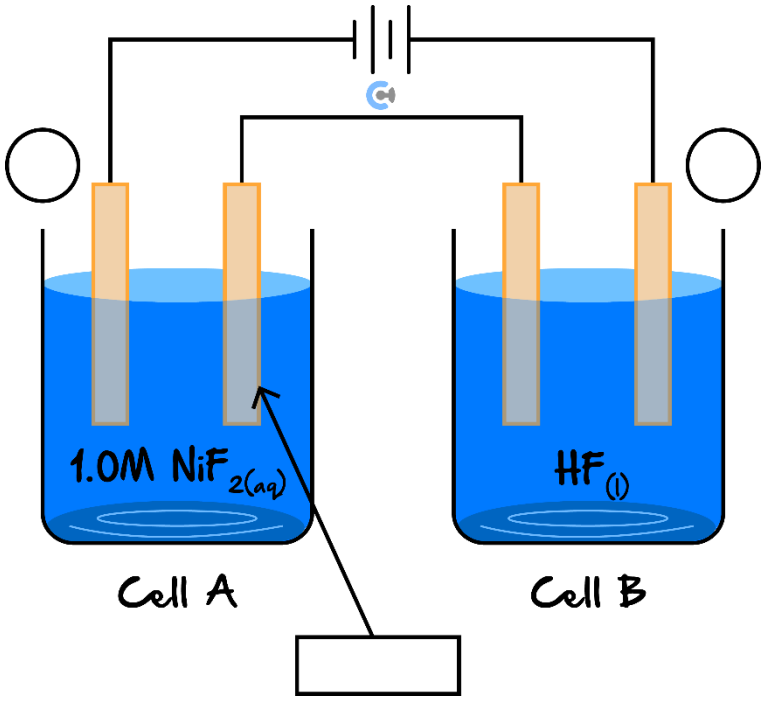
ii. Electrode *D*. (1 mark)

_____

Space for Personal Notes

Question 28 (6 marks)

The following connected cell is constructed and is connected to a power source.



a. Write the polarities of the two electrodes in the circles provided above. (1 mark)

b. Label the electrode labelled in the diagram as the cathode or the anode. (1 mark)

c. Write the half-equations occurring at the anode of:

i. Cell *A*. (1 mark)

_____

ii. Cell *B*. (1 mark)

_____

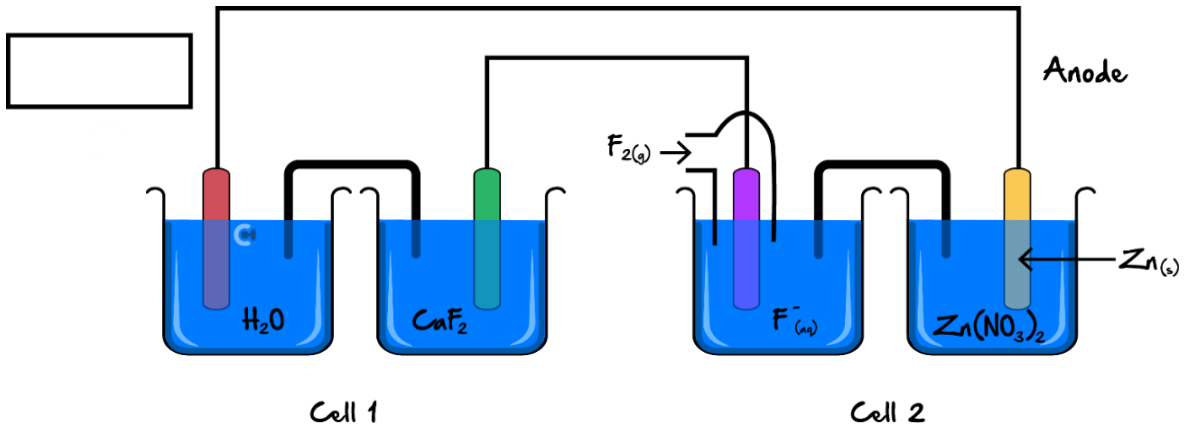
d. Find the total voltage that the power source must supply for the cell to operate. (2 marks)

_____

_____

_____

Question 29 (7 marks)



a. In the box provided above, label whether the electrode indicated is the anode or cathode. (1 mark)

b.

i. Using relevant half-equations, justify whether cell 2 is a galvanic or electrolytic cell. (2 marks)

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ii. Hence or otherwise, determine the overall reaction occurring in cell 1. (1 mark)

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iii. If the $F^-(aq)/F_2(g)$ half cell is swapped out for a $Cu^{2+}(aq)/Cu(s)$ half cell, explain whether the entire cell will operate. (3 marks)

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Section D: [2.4] - Electroplating (Checkpoints) (37 Marks)

Sub-Section [2.4.1]: Identify The Electroplating Setup (Location of Object) & Find The Electroplating Reactions

Question 30 (1 mark)

When electroplating a metallic key with Cu metal:

A. The key must be connected to the negative terminal of the power supply.

B. The electrolyte can be a solution of $CuSO_4$.

C. The anode can be made from Cu metal.

D. All of the above.

Question 31 (1 mark)

A student wanted to cover an iron key with copper metal. Which of the following experimental setups is **incorrect**?

A. The student connected the key to the negative terminal of a power supply.

B. The student used copper (II) sulphate solution as the electrolyte.

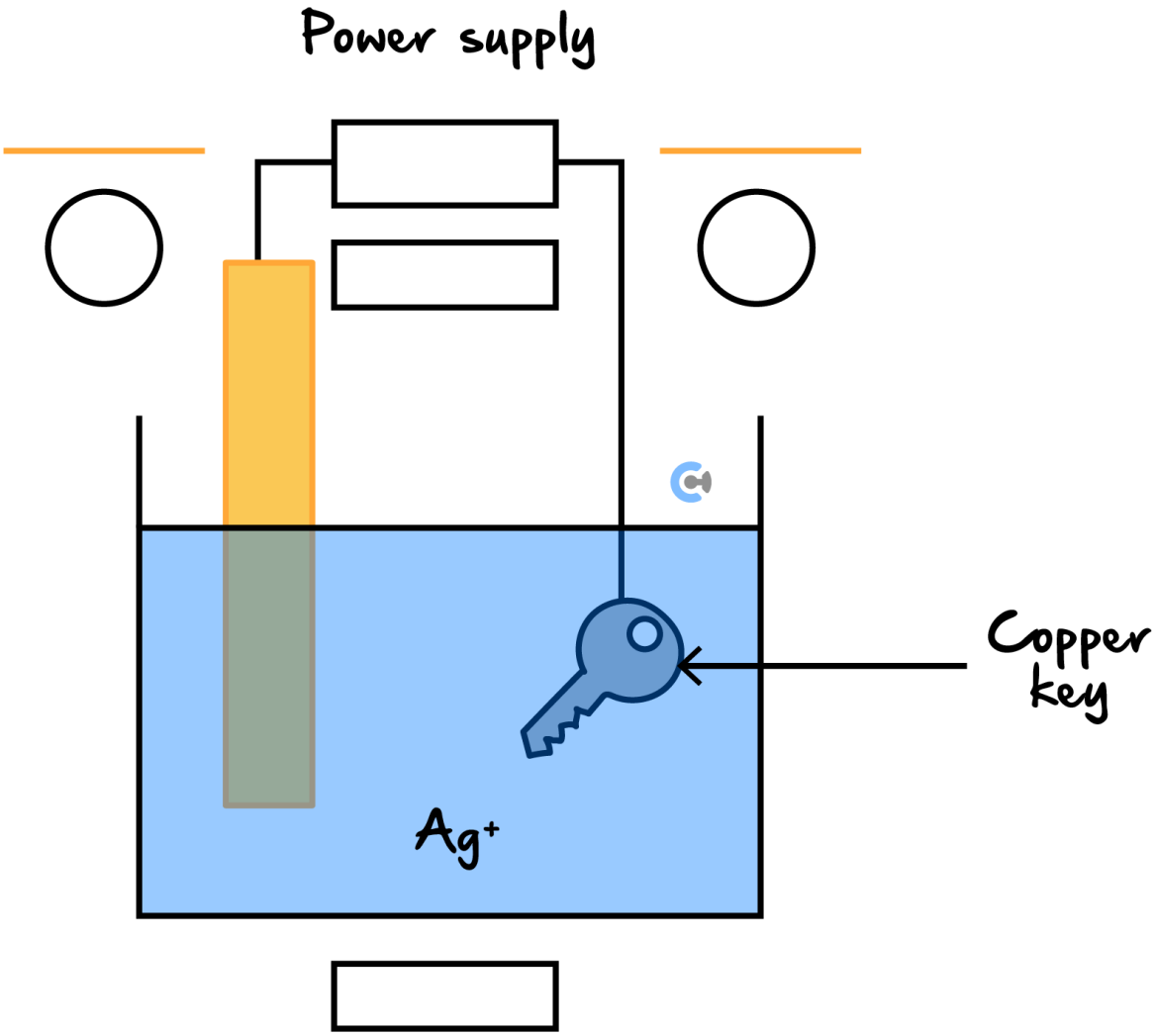
C. The student used an iron rod as the cathode.

D. The student connected an iron rod to the positive terminal of a power supply.

Space for Personal Notes

Question 32 (10 marks)

The following electroplating apparatus has been set up by a student A. 1.2 M solution of $AgNO_3$ was used as an electrolyte.



a. Label the following on the diagram.

i. The cathode and anode on the **orange** lines. (1 mark)

ii. The charges of the cathode and anode in the circles. (1 mark)

iii. An arrow showing the direction of the current in the **purple** box. (1 mark)

iv. An arrow showing the direction of Ag^+ ions in the **blue** box. (1 mark)

b. Determine the oxidation and reduction half-reactions for this cell. (1 mark)

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_____

c. The student runs the electroplating apparatus for 30 minutes and makes several observations.

- The key increases in mass.
- There are bubbles produced at the silver electrode once 15 minutes have passed.
- The silver electrode increases in mass.

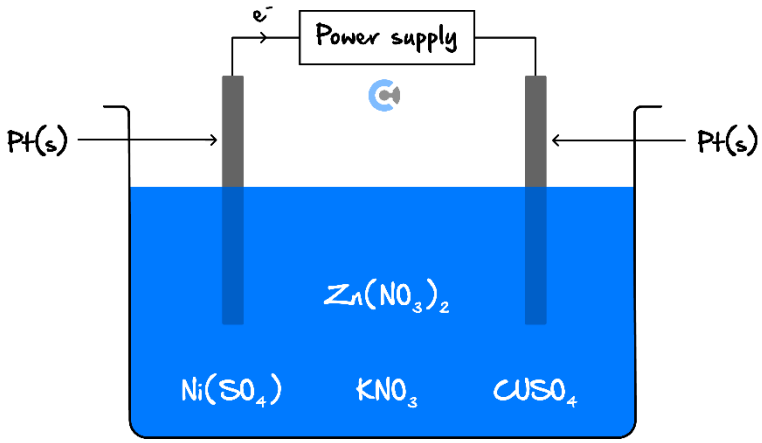
Evaluate these observations. If the observation is impossible, explain why. (5 marks)

Space for Personal Notes

Sub-Section [2.4.2]: Find Next Order Reactions During Electrolysis

Question 33 (8 marks)

Ziggy sets up an electrolytic cell containing two platinum electrodes with 0.1 M of $CuSO_4(aq)$, $NiSO_4(aq)$, $Zn(NO_3)_2(aq)$ and $KNO_3(aq)$ as shown in the diagram below:



a. State and explain what metal will accumulate on the cathode immediately when the power supply is turned on. (2 marks)

b. Ziggy notes that after 5 minutes, the solution, which was initially blue, has turned transparent.

i. Explain this observation. (1 mark)

ii. At this point, explain which metal is being electroplated at the cathode. (2 marks)

c. After 30 minutes of the cell running, Ziggy notices bubbling occurring at the cathode. His friend, Gain, claims that "the bubbling is due to impurity metal ions in the solution reacting with water." Evaluate Gain's statement and explain the reason for the bubbling. (3 marks)

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Space for Personal Notes

Sub-Section [2.4.3]: Apply Faraday's Laws To Electroplating Calculations

Question 34 (4 marks)

Aanya sets up an electrolytic cell and leaves it running for a period of time.

a. The cell is running for 30 minutes with 4.00 A of current running through the cell. Calculate the electrical charge running through the cell. (2 marks)

b. Aanya decides to decrease the time that the cell runs to 10 minutes and finds that 900 C of electrical charge runs through the cell. Calculate the current running through the cell. (2 marks)

Space for Personal Notes

Question 35 (5 marks)

a. Daniel passes 2.450 mol electrons through a cell. Calculate the amount of electrical charge that passes through. (2 marks)

b. In another experiment, Daniel runs the cell for 45 minutes, at 4.20 A. Calculate the number of electron moles running through the cell. (3 marks)

Space for Personal Notes

Question 36 (5 marks)

An electrolytic cell was set up using an unknown, molten metal salt, MBr_3. A current of $1.25\ A$ was passed through the molten compound for 50.0 minutes to deposit $0.675\ g$ of the metal.

a. Write a balanced half-equation for the anode and cathode reactions in this electrolytic cell. (2 marks)

b. Calculate the charge passed through the cell. (1 mark)

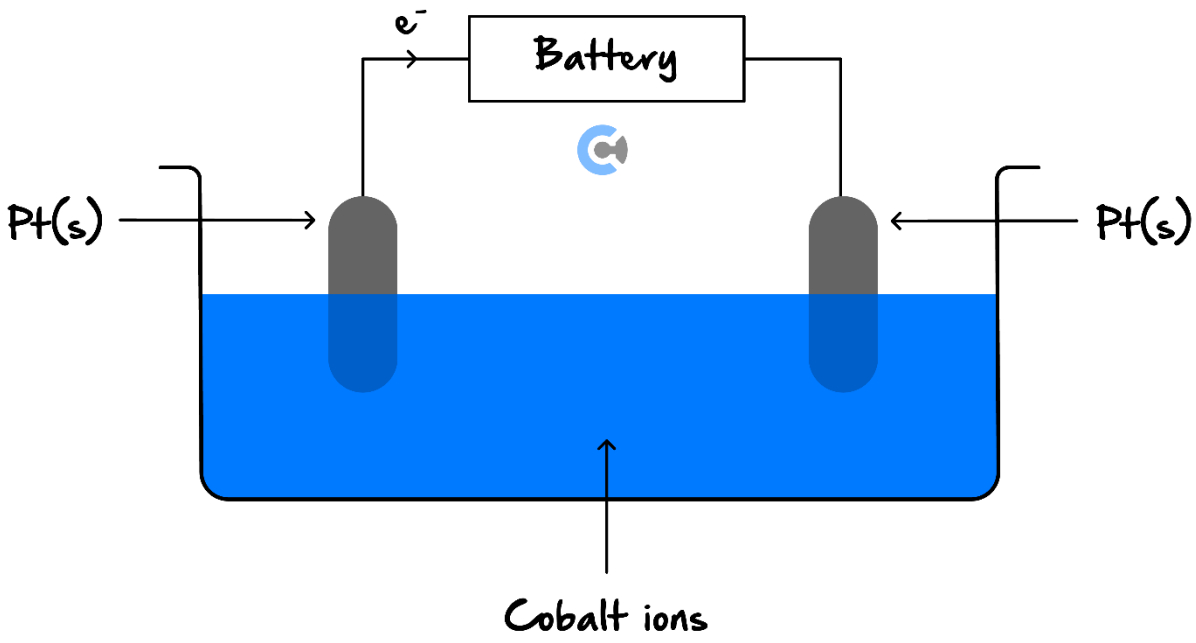
c. Calculate the moles of metal deposited. (2 marks)

d. Identify the metal deposited. (2 marks)

Space for Personal Notes

Question 37 (3 marks)

Kynan sets up a cell shown below:



Kynan runs the cell for 20.0 minutes with 5.50 A running through the cell and finds that 2.0 g of metal has been deposited on the cathode.

Find the charge of the cobalt cation.

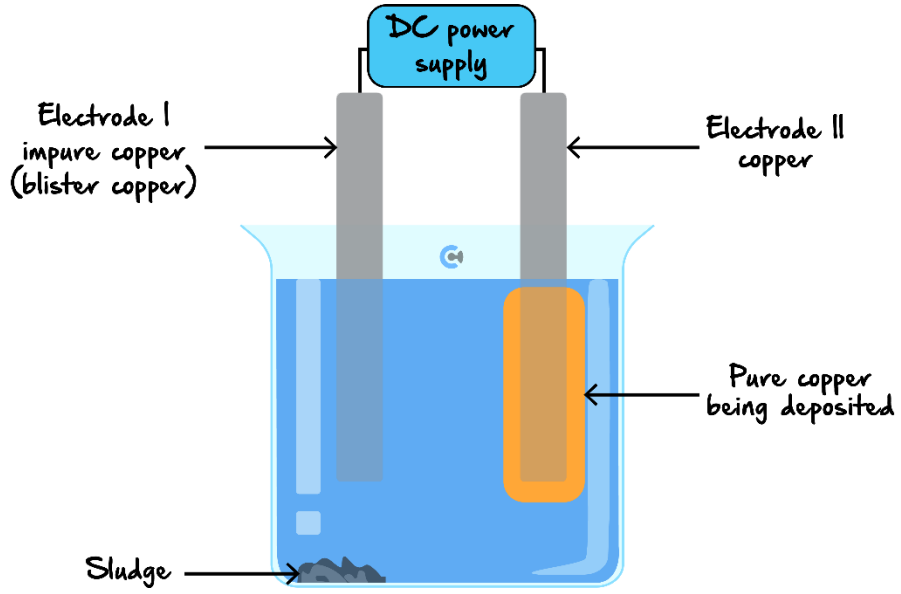
Space for Personal Notes

Section E: [2.1 – 2.4] – Overall (VCAA Qs) (89 Marks)

The following information applies to the two questions that follow.

Inspired from VCAA Chemistry Exam 2015
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2015/2015chem-w.pdf

An electrolytic cell is set up to obtain pure copper from an impure piece of copper called 'blister copper'. The electrolyte solution contains both copper (II) sulphate and sulphuric acid. The blister copper, Electrode I, contains impurities such as zinc, cobalt, silver, nickel and iron. The cell voltage is adjusted so that only copper is deposited on Electrode II. Sludge, which contains some of the solid metal impurities present in the blister copper, forms beneath Electrode I. The other impurities remain in the solution as ions.
The diagram below represents the cell:



Question 38 (1 mark)

The solid metal impurities that are found in the sludge are:

A. Nickel and cobalt.

B. Cobalt, nickel and iron.

C. Nickel and iron.

D. Silver

Question 39 (1 mark)

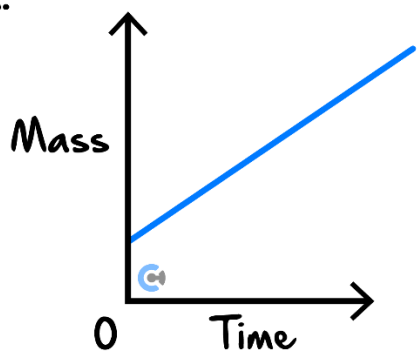
Which of the following correctly shows both the equation for the reaction occurring at the cathode and the polarity of Electrode I?

	Cathode reaction	Polarity of Electrode I
A.	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	Positive
B.	$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$	Negative
C.	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	Negative
D.	$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$	Positive

Question 40 (1 mark)

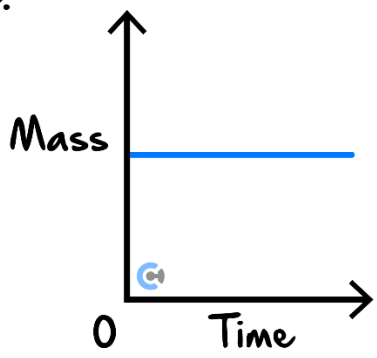
Which one of the following graphs best shows the change in mass of Electrode I over a period of time, starting from the moment the power supply is connected?

A.

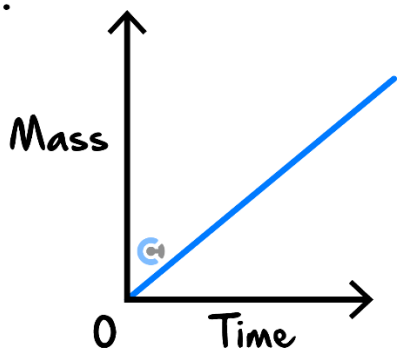


B.

C.

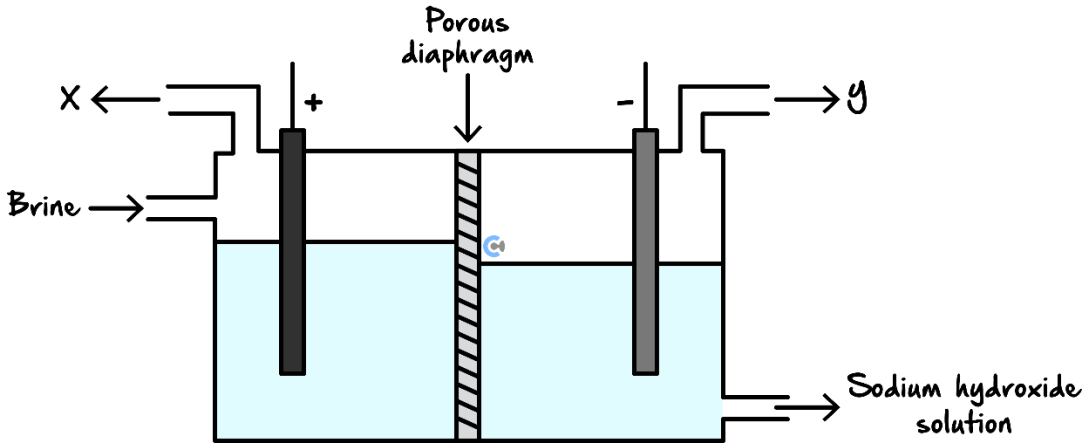


D.



The following information applies to the three questions that follow.

The diagram below represents a diaphragm cell used for the commercial production of chlorine gas:



Question 41 (1 mark)

Inspired from VCAA Chemistry Exam 2007
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2007chem2.pdf

The gases labelled *X* and *Y* are:

	X	***Y***
A.	Chlorine	Oxygen
B.	Oxygen	Chlorine
C.	Chlorine	Hydrogen
D.	Hydrogen	Chlorine

Question 42 (1 mark)

Inspired from VCAA Chemistry Exam 2007
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2007chem2.pdf

One function of the porous diaphragm in the cell is to:

A. Act as a catalyst to increase the rate of the reaction.

B. Allow movement of ions between the cell compartments.

C. Prevent sodium ions from entering the solution near the anode.

D. Prevent the electrolyte from making contact with the gases produced.

Question 43 (1 mark)

Inspired from VCAA Chemistry Exam 2007
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2007chem2.pdf

A highly concentrated salt solution, brine, is used as the electrolyte in this cell.
The main reason that a highly concentrated, rather than a dilute, solution is used is to:

A. Allow an electric current to pass through the cell.

B. Produce chlorine gas, in preference to oxygen gas.

C. Allow sodium hydroxide to be separated from the salt by crystallisation.

D. Create non-standard conditions that ensure hydrogen gas production.

Question 44 (1 mark)

Inspired from VCAA Chemistry Exam 2009
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2009chem2-w.pdf

Lithium metal is manufactured by electrolysis of lithium salts.
Which of the following would be the best choice for the electrolyte and the anode in a commercial cell?

	Electrolyte	Anode
A.	LiCl solution	Iron rod
B.	Molten LiCl	Iron rod
C.	LiCl solution	Carbon rod
D.	Molten LiCl	Carbon rod

Space for Personal Notes

Question 45 (1 mark)

Inspired from VCAA Chemistry Exam 2023
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2023/NHT/2023chem-nht-w.pdf

In the electrolysis of 6 M sodium chloride solution, NaCl(aq), the amount of charge required to form one mole of NaOH(aq) is:

A. $4.8 \times 10^4\ C$

B. $9.7 \times 10^4\ C$

C. $1.9 \times 10^5 C$

D. $3.9 \times 10^5 C$

Question 46 (1 mark)

Inspired from VCAA Chemistry Exam 2013
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2013/2013chem-w.pdf

The lead-acid battery used in cars consists of secondary galvanic cells.

The following equations relate to the lead-acid battery:

$$PbSO_4(s) + 2e^- \rightleftharpoons Pb(s) + SO_4{}^{2-}(aq) \qquad E^\circ = -0.36\ V$$

$$PbO_2(s) + SO_4^{2-}(aq) + 4H^+(aq) + 2e^- \rightleftharpoons PbSO_4(s) + 2H_2O(l) \qquad E^\circ = 1.69\ V$$

When an external power source is used to recharge a flat lead-acid battery:

A. The concentration of sulphuric acid decreases.

B. $PbSO_4$ is both oxidised and reduced.

C. The mass of metallic lead decreases.

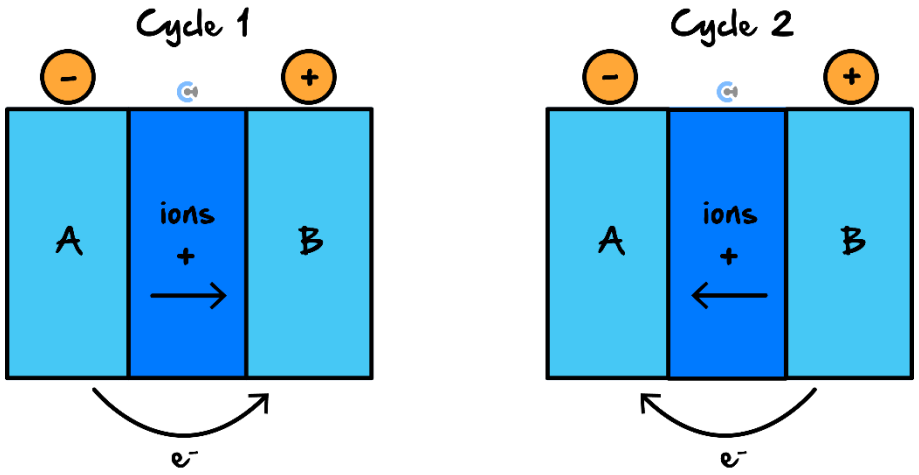
D. PbO_2 is oxidised to Pb.

Space for Personal Notes

Question 47 (1 mark)

Inspired from VCAA Chemistry Exam 2018
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2018/nht/2018chem-nht-w.pdf

The following diagrams represent the operation of a secondary cell during recharge and discharge, in no particular order. The diagrams of the circuits are not complete.



Which of the options below correctly describes the cell and its operation?

	Cycle 1	Cycle 2
A.	Energy produced	Anode is positive
B.	Spontaneous reaction	Energy produced
C.	Anode is positive	Energy required
D.	Spontaneous reaction	Cathode is positive

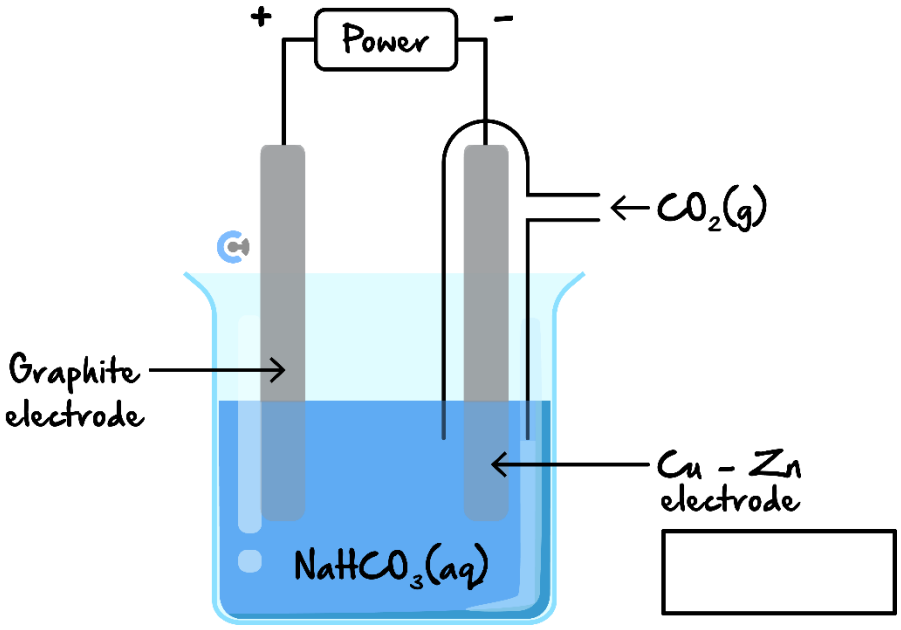
Space for Personal Notes

Question 48 (8 marks)

Inspired from VCAA Chemistry Exam 2020
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2020/2020chem-w.pdf

The electrolysis of carbon dioxide gas, CO_2, in water is one way of making ethanol, C_2H_5OH.

The diagram below shows a CO_2-H_2O electrolysis cell. The electrolyte used in the electrolysis cell is sodium bicarbonate solution, $NaHCO_3(aq)$.



The following half-cell reactions occur in the CO_2-H_2O electrolysis cell.

$$O_2(g) + 2H_2O(l) + 4e^- \rightleftharpoons 4OH^-(aq) \qquad E^\circ = +0.40\ V$$

$$2CO_2(g) + 9H_2O(I) + 12e^- = C_2H_3OH(l) + 12OH^-(aq)\ ) \qquad E^\circ = -0.33\ V$$

a. Identify the Cu-Zn electrode as either the anode or the cathode in the box provided in the diagram above. (1 mark)

b. Determine the applied voltage required for the electrolysis cell to operate. (1 mark)

_____

c. Write the balanced equation for the overall electrolysis reaction. (1 mark)

_____

_____

d. Identify the oxidising agent in the electrolysis reaction. Give your reasoning using oxidation numbers. (2 marks)

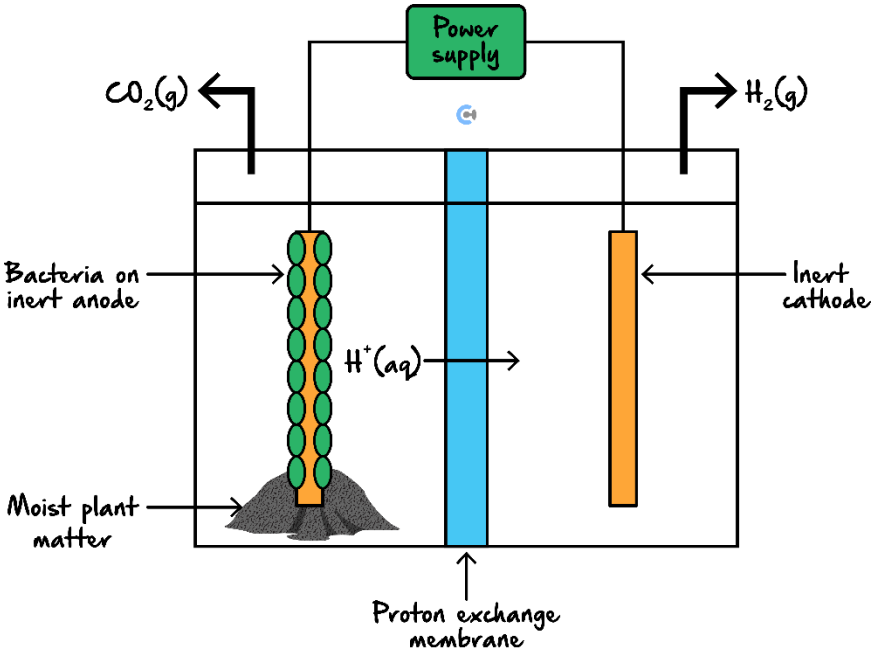
e. A current of 2.70 A is passed through the CO_2-H_2O electrolysis cell. The cell has an efficiency of 58%. Calculate the time taken, in minutes, for this cell to consume $6.05 \times 10^{-3}\ mol$ of $CO_2(g)$. (3 marks)

Space for Personal Notes

Question 49 (4 marks)

Inspired from VCAA Chemistry Exam 2012
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2012/2012chem2-w.pdf

Hydrogen gas is an energy source. Researchers are investigating the production of hydrogen gas in a microbial electrolysis cell.
The cell is made up of an anode half-cell and a cathode half-cell. A proton exchange separates the half-cells membrane, as shown in the diagram below:



A number of reactions take place in the cell, resulting in the production of hydrogen. These reactions are summarised below.

Anode half-cell:

- The anode half-cell contains moist plant matter and electrochemically active bacteria that live on an inert anode.
- The gaseous mixture that is present in the half-cell does not contain oxygen.
- The moist plant matter ferments to produce ethanoic acid (CH_3COOH). Bacteria on the anode consume the ethanoic acid and release hydrogen ions, electrons and carbon dioxide gas. A small voltage is then applied to reduce the H^+ ions.

Cathode half-cell:

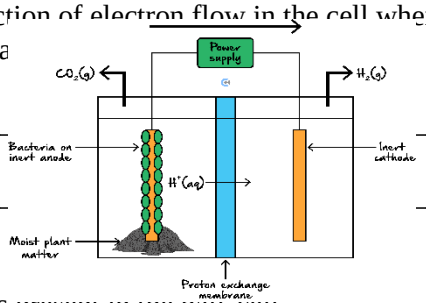
- The cathode half-cell contains an inert cathode.
- The gaseous mixture that is present in the half-cell does not contain oxygen.
- The released hydrogen ions and electrons react to form hydrogen gas, as shown in the equation below:

$$2H^+(aq) + 2e^- \rightarrow H_2(g)$$

a. Ethanoic acid is converted to carbon dioxide gas and H^+ ions at the anode.

Write an equation for this reaction. (1 mark)

b. In the diagram above, use one arrow to indicate the direction of electron flow in the cell when an external voltage is supplied to the cell by the power supply. (1 ma



c. Hydrogen gas is not produced at the cathode if oxygen is present in the half-cell.
Write a balanced half-equation to show the product that would be produced at the cathode if oxygen were present in the half-cell. (1 mark)

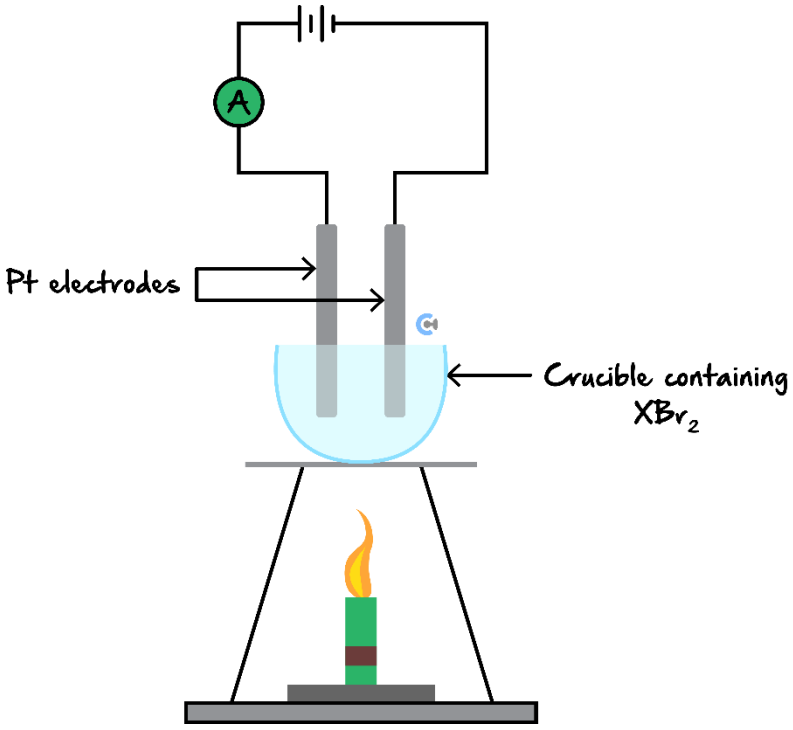
d. Describe one difference between an electrolysis cell and a traditional fuel cell. (1 mark)

Space for Personal Notes

Question 50 (6 marks)

Inspired from VCAA Chemistry Exam 2012
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2012/2012chem2-w.pdf

A teacher demonstrated the process of electrolysis of a molten salt using an unknown metal salt, XBr_2.
The apparatus was set up as shown below:



After the demonstration, the students were provided with the following information:

- A current of 1.50 amperes was applied for 30.0 minutes.
- 2.90 *g* of metal *X* was produced.

a. Write a balanced half-equation for the anode reaction in this electrolytic cell. (1 mark)

_____

_____

b.

i. Determine the amount, in mol, of metal X that was deposited on the cathode. (3 marks)

_____

_____

_____

_____

_____

ii. Identify metal X. (2 marks)

_____

_____

_____

Question 51 (8 marks)

Inspired from VCAA Chemistry Exam 2023
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2023/NHT/2023chem-nht-w.pdf

Copper metal, Cu, is used to conduct electricity through a printed circuit board (PCB). One use of PCBs is in computers. Electrolysis can be used to deposit Cu on PCBs.

a. State the structural feature that is present in an electrolytic cell but absent in a galvanic cell. (1 mark)

_____

b. State an advantage of using Cu over platinum, Pt, as the anode in an electrolysis cell used to deposit Cu on PCBs. (1 mark)

_____

_____

c. In a particular electrolysis cell, a number of PCBs have copper deposited on them. The electrolyte used in the cell is $Cu(NO_3)_2(aq)$. The electrolysis cell is operating at 4.0 amps.

Assuming 100% cell efficiency, for how many seconds does the cell need to operate to deposit 5.08 g of copper on the PCBs? (4 marks)

d. Another electrolysis cell is set up, at standard conditions, with two Pt electrodes and 1M sodium hydroxide, NaOH as the electrolyte.

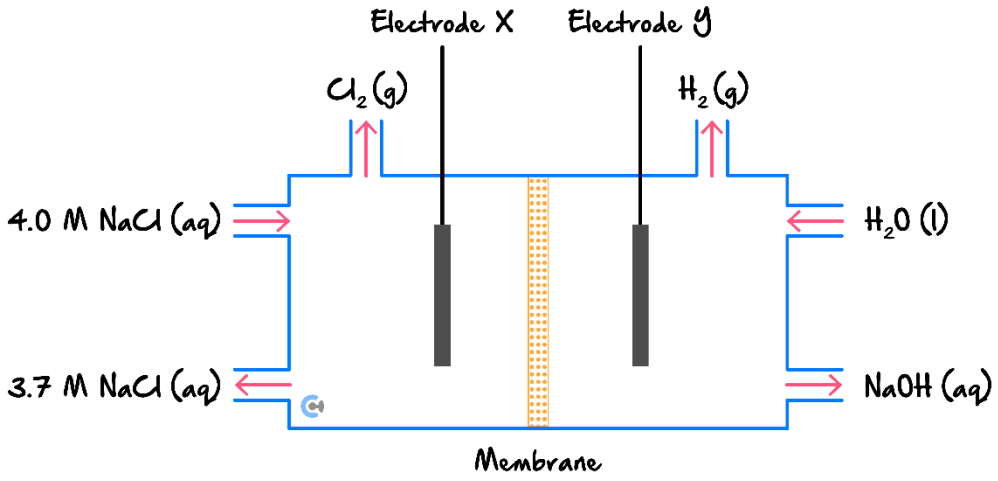
Write the equations for the two half-reactions that occur. (2 marks)

Space for Personal Notes

Question 52 (8 marks)

Inspired from VCAA Chemistry Exam 2022
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2022/NHT/2022ChemistryNHT-w.pdf

Chlorine gas, Cl_2, can be produced from the electrolysis of 4.0 *M* sodium chloride, NaCl(aq). The diagram below shows a simplified model of the electrolysis cell for this process:



a.

i. Which electrode- *X* or *Y*- is the anode when the electrolysis cell is operating? (1 mark)

_____

_____

ii. Name or write the formula for the ion that passes through the membrane between the half-cells to allow the electrolysis cell to operate. (1 mark)

_____

_____

b.

i. Write the half-equation for the production of $Cl_2(g)$. (1 mark)

_____

_____

ii. With reference to the electrochemical series, explain why $Cl_2(g)$ is produced instead of $O_2(g)$. (2 marks)

_____

_____

_____

_____

iii. Calculate the mass of $Cl_2(g)$ that would be produced from 1.80×10^6 coulombs of charge. Assume that $Cl_2(g)$ is the only product at Electrode X. (3 marks)

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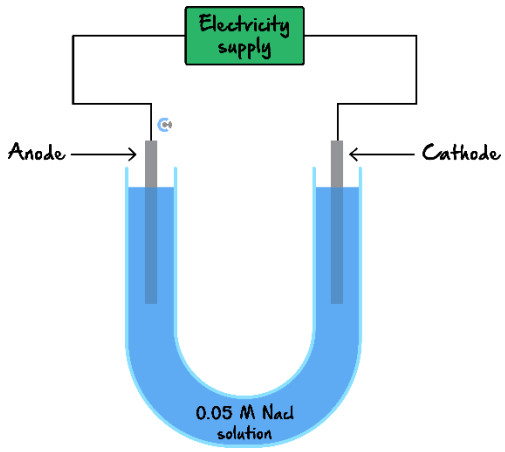
Space for Personal Notes

Question 53 (9 marks)

Inspired from VCAA Chemistry Exam 2019
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2019/NHT/2019chem-nht-w.pdf

A student electrolysed a 0.05 *M* sodium chloride, NaCl, solution using graphite electrodes, as shown in the setup below:



Several drops of phenol red were added to the solution next to each electrode.

The following observations were made as the reactions proceeded:

Polarity of electrode	Observation	Colour of phenol red
Positive	Bubbles formed at the electrode	Yellow
Negative	Bubbles formed at the electrode	Red

a. What colour was observed at the cathode as the electrolysis proceeded? (1 mark)

_____

_____

b. Use the electrochemical series to predict the gas expected to be formed at each electrode. (2 marks)

_____

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_____

_____

c. Molten NaCI can be electrolysed commercially. The melting point of NaCl is 801°C.

i. Write the overall equation for this electrolysis. (1 mark)

_____

_____

ii. Give two reasons why it would be difficult to carry out this electrolysis in a school. (2 marks)

_____

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d. The student constructs the summary table below to compare the processes that take place in galvanic cells and electrolytic cells.

Complete the table by writing 'true' or 'false' in each space provided. (3 marks)

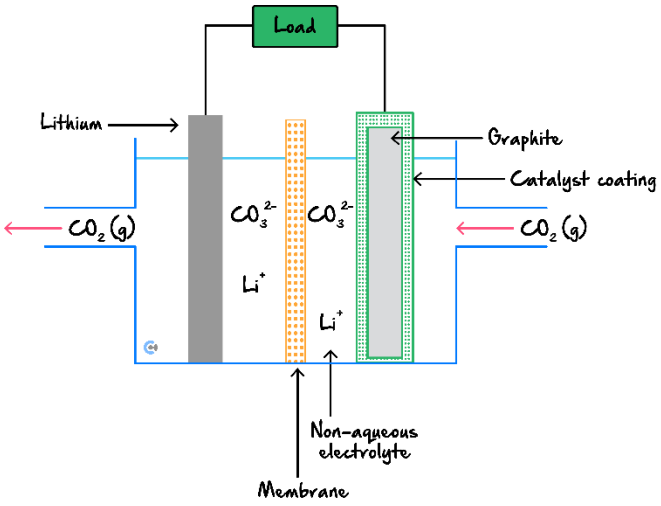
Process	Galvanic cells	Electrolytic cells
Oxidation occurs at the cathode		
Chemical energy is converted to electrical energy		
Spontaneous reactions take place		

Space for Personal Notes

Question 54 (7 marks)

Inspired from VCAA Chemistry Exam 2020
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2020/2020chem-w.pdf

Research scientists are developing a rechargeable lithium-carbon dioxide, Li-CO_2, battery. The rechargeable Li-CO_2 battery is made of lithium metal, carbon in the form of graphite (coated with a catalyst) and a non-aqueous electrolyte that absorbs CO_2.
A diagram of the rechargeable Li-CO_2 cell is shown below. One Li-CO_2 cell generates 4.5 V.



a. When the Li-CO_2 cell generates electricity, the two half-cell reactions are:

$$4Li^+ + 3CO_2 + 4e^- \rightarrow 2Li_2CO_3 + C$$

$$Li \rightarrow Li^+ + e^-$$

Write the equation for the overall recharge reaction. (1 mark)

_____

_____

b. During discharge, lithium carbonate, Li_2CO_3, deposits break away from the electrode.

Describe how this might affect the performance of the battery. (2 marks)

_____

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_____

c. Explain why it is unsafe to use an aqueous electrolyte in the design of the Li-CO_2 battery. Include appropriate equations in your answer. (3 marks)

d. Could the Li-CO_2 battery be used to reduce the amount of $CO_2(g)$ in the atmosphere? Give your reasoning. (1 mark)

Question 55 (7 marks)

Inspired from VCAA Chemistry Exam 2016
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2016/2016chem-amd-w.pdf

The lithium-ion battery is a secondary cell that is now widely used in portable electronic devices. In these batteries, lithium ions, Li^+, move through a special non-aqueous electrolyte between the two electrodes. The batteries are housed in sealed containers to ensure that no moisture can enter them.

Both electrodes are made up of materials that allow the lithium ions to move into and out of their structures. The anode consists of LiC_6, where lithium is embedded in the graphite structure. Lithium cobalt oxide, $LiCOO_2$, is commonly used as the material in the cathode. The reaction at the cathode is quite complex. When the cell discharges, Li^+ ions move out of the anode and enter the cathode.

During discharge, the half-cell reaction at the anode is:

$$LiC_6 \rightarrow Li^+ + e^- + C_6$$

a. During discharge, what is the polarity of the graphite electrode? (1 mark)

b. Write the half-equation for the reaction that occurs at the cathode of a lithium-ion battery when it is recharged. (1 mark)

_____

_____

c. In a lithium-ion battery, lithium metal must not be in contact with water.

Explain why and justify your answer with the use of appropriate equations. (3 marks)

_____

_____

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d. Identify **one** design feature of the lithium-ion battery that enables it to be recharged (1 mark)

_____

_____

e. What is **one** advantage of using a secondary cell compared to using a fuel cell? (1 mark)

_____

_____

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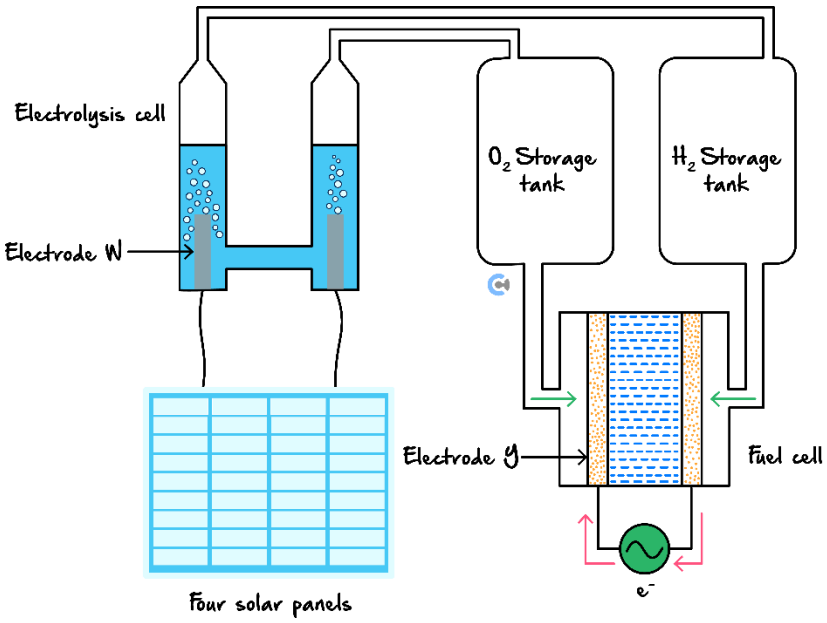
Question 56 (11 marks)

Inspired from VCAA Chemistry Exam 2018
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2018/2018chem-w.pdf

An energy company investigates the feasibility of supplying energy while reducing greenhouse gas emissions. Solar panels collect energy from the sun during daylight hours, and this energy is used to electrolyse water, H_2O to produce oxygen gas, O_2, and hydrogen gas, H_2. These gases are stored separately and then used in a fuel cell to produce energy when required.

The diagram below shows a simplified representation of the setup used:



a.

i. State the polarity of Electrode *W* in the electrolysis cell. (1 mark)

_____

_____

ii. The fuel cell operates in an alkaline environment.

Write the half-equation for the reaction that takes place at Electrode *Y*. (1 mark)

_____

_____

b. Each of the four solar panels produces an average current of $5.20\ A$ and operates over an eight-hour period. The electrical energy generated is used by the electrolysis cell to produce O_2 and H_2.

i. Calculate the amount, in moles, of H_2 produced by the electrolysis cell. (3 marks)

_____

_____

_____

_____

_____

_____

ii. Determine the pressure this amount of H_2 gas would exert at SLC in a $10.0\ L$ H_2 tank. (1 mark)

_____

_____

c. The fuel cell produces 3553 kJ when 20 mol of H_2 is consumed. Another possible energy source is a generator using petrodiesel as a fuel. The generator operates with an efficiency of 35%. A particular petrodiesel containing a range of hydrocarbons has been found to have a heat content of 45 $kJ\ g^{-1}$. The formula for this petrodiesel can be represented by $C_{12}H_{24}$ ($M = 168\ g\ mol^{-1}$).

i. Calculate the mass of petrodiesel required to produce 3553 kJ. (2 marks)

ii. Calculate the mass of $CO_2(g)$ released when 3553 kJ of energy is produced from petrodiesel. (2 marks)

iii. How would the mass of CO_2 produced from the combustion of this petrodiesel compared with the mass of CO_2 produced by the fuel cell? (1 mark)

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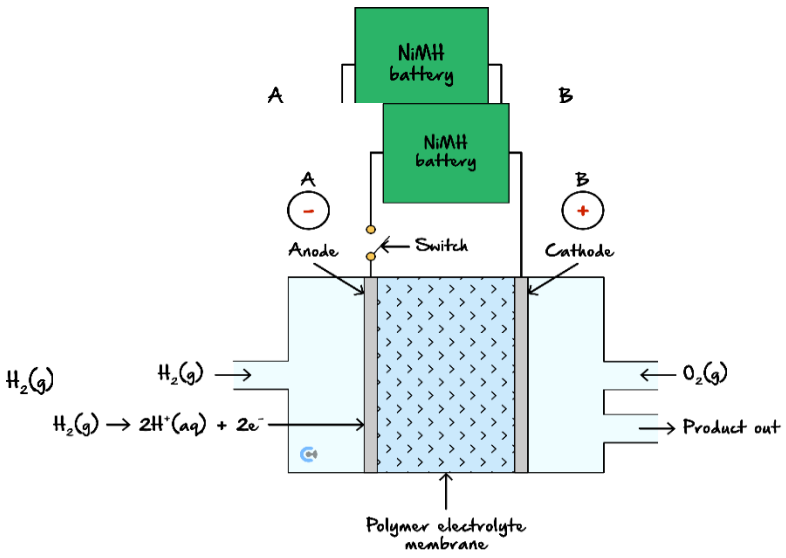
Question 57 (11 marks)

Inspired from VCAA Chemistry Exam 2016
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2016/2016chem-amd-w.pdf

A car manufacturer is planning to sell hybrid cars powered by a type of hydrogen fuel cell connected to a nickel metal hydride, NiMH, battery.

A representation of the hydrogen fuel cell is given below:



The overall cell reaction is:

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

a.

i. On the diagram above, indicate the polarity of the anode and the cathode in circles A and B, and identify the product of the reaction in the box C. (2 marks)

ii. Write an equation for the reaction that occurs at the cathode when the switch is closed. (1 mark)

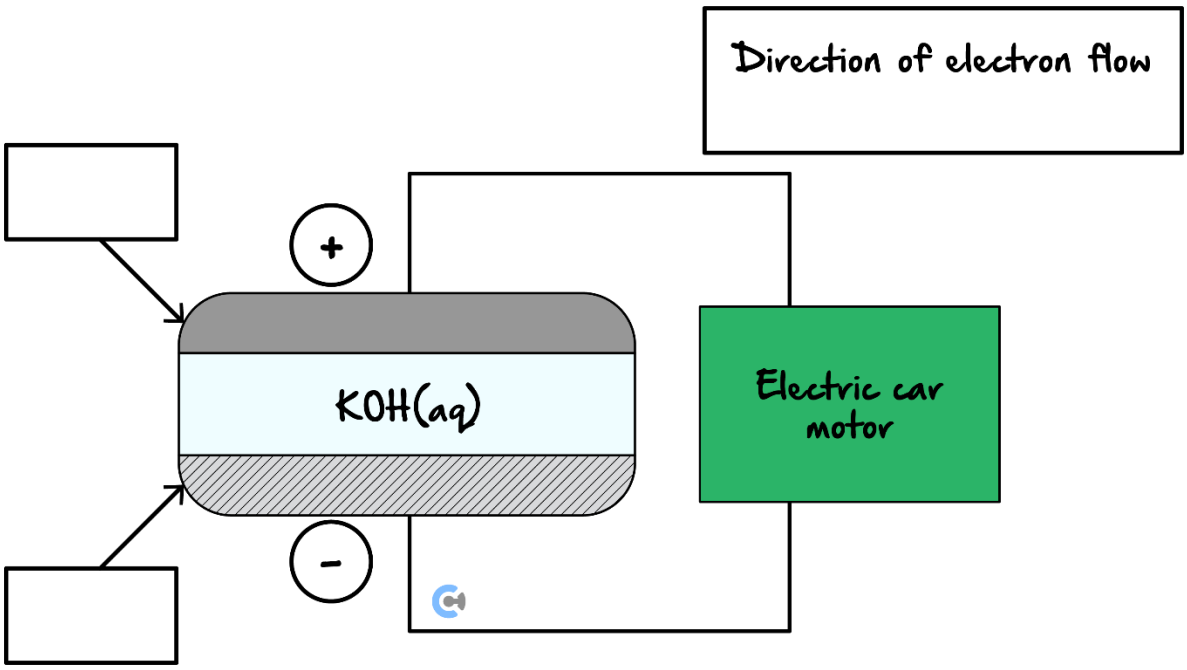
Cathode reaction _____

iii. Identify one advantage and one disadvantage of using this fuel cell instead of a petrol engine to power the car. (2 marks)

Advantage_____

Disadvantage _____

b. The storage battery to be used in the hybrid cars is comprised of a series of nickel metal-hydride cells, NiMH cells. MH represents a metal hydride alloy that is used as one electrode. The other electrode contains nickel oxide hydroxide, NiOOH. The electrolyte is aqueous KOH.



The simplified equation for the reaction at the anode while **recharging** is:

$$Ni(OH)_2(s) + OH^-(aq) \rightarrow NiOOH(s) + H_2O(l) + e^-$$

The simplified equation for the reaction at the cathode while **recharging** is:

$$M(s) + H_2O(l) + e^- \rightarrow MH(s) + OH^-(aq)$$

i. What is the overall equation for the discharging reaction? (1 mark)

_____

_____

ii. In the boxes on the diagram above, indicate which is the MH electrode and which is the NiOOH electrode. (1 mark)

iii. In the bold box provided above the cell diagram, use an arrow, → or ← to indicate the direction of the electron flow as the cell is discharging. (1 mark)

iv. The battery discharged for 60 minutes, producing a current of 1.15 *A*.

What mass, in grams, of NiOOH would be used during this period? (3 marks)

_____

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