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VCE Chemistry ¾
Secondary Cells & Connected Cells [0.14]
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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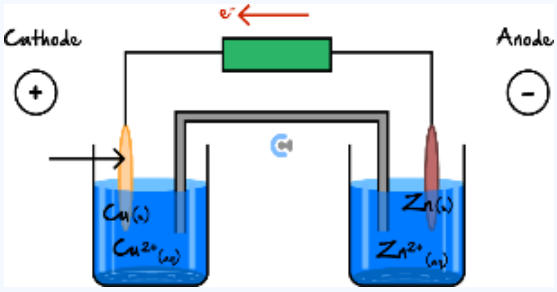
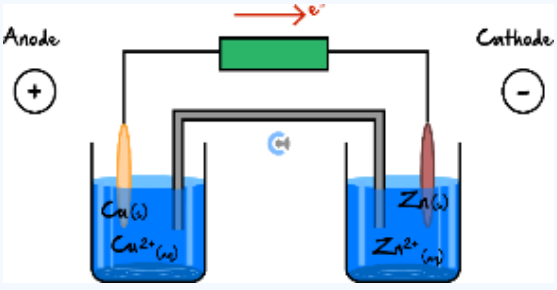
Section A: Recap (3 Marks)

Learning Objective: [2.3.1] – Write Discharge & Recharge Reactions in Secondary Cells

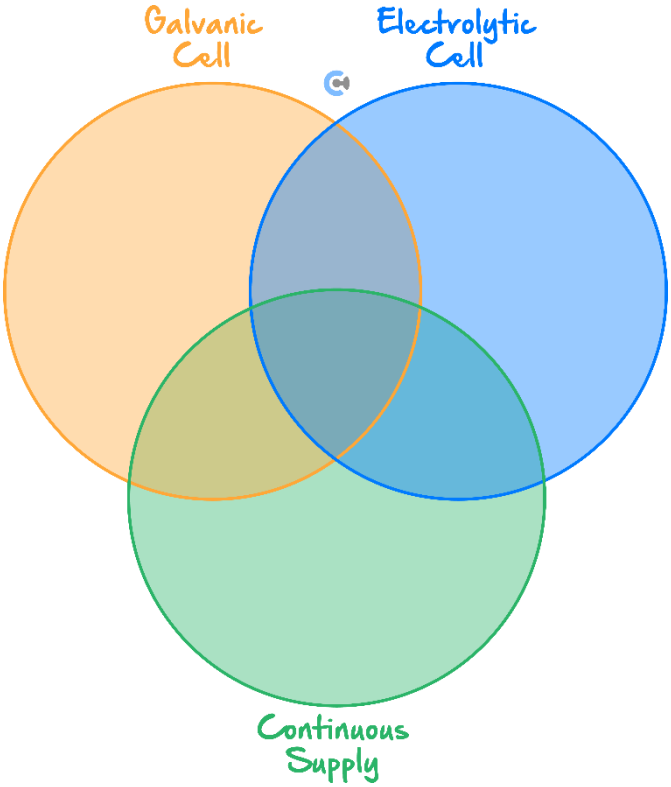
Primary Cells	Secondary Cells
[rechargeable] / [non-rechargeable]	[rechargeable] / [non-rechargeable]

Discharge (Galvanic)	Recharge (Electrolytic)
	
Electron flow: [left] / [right]	Electron flow: [left] / [right]
Cathode: **Anode:**	**Cathode:** **Anode:**
Left Electrode Polarity: [+] / [–]	Left Electrode Polarity: [+] / [–]
Left Electrode Type: [cathode] / [anode]	Left Electrode Type: [cathode] / [anode]

- **During Discharge / Recharge:**
  - Polarities [stays same] / [swap].
  - Type of electrode (cathode / anode) [stays same] / [swap].

Definition

Learning Objective: [2.3.2] – Identify Factors which Affect Rechargeability & Compare Similarities / Differences between Secondary Cells and Other Cells

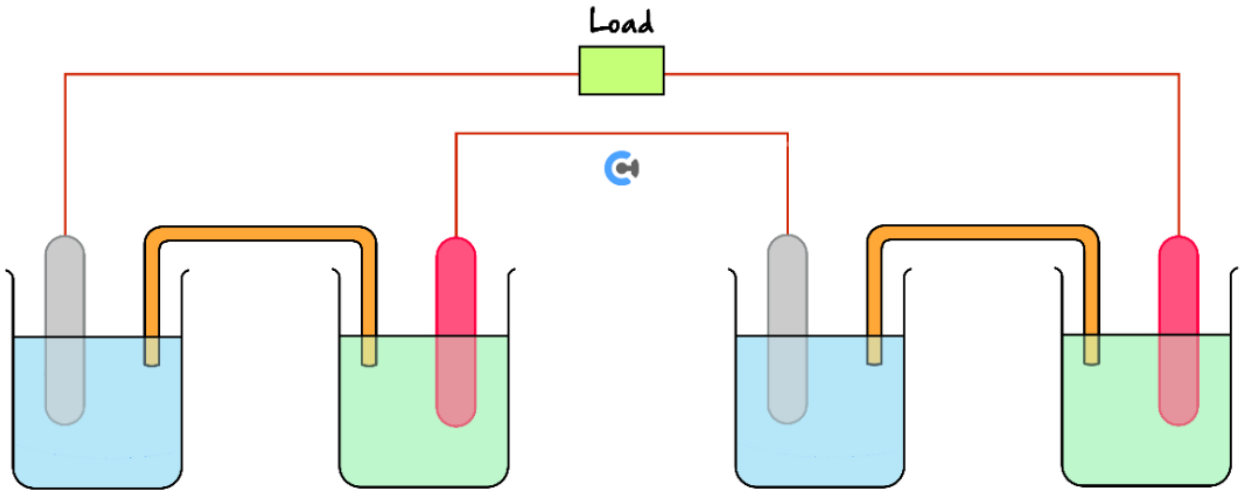


Primary Cell	Secondary Cell
[rechargeable] / [non-rechargeable]	[rechargeable] / [non-rechargeable]
Can act as [galvanic] / [electrolytic] cell.	Can act as [galvanic] / [electrolytic] cell.
[chemical to electrical] / [electrical to chemical]	[chemical to electrical] / [electrical to chemical]
[cheap] / [expensive]	[cheap] / [expensive]

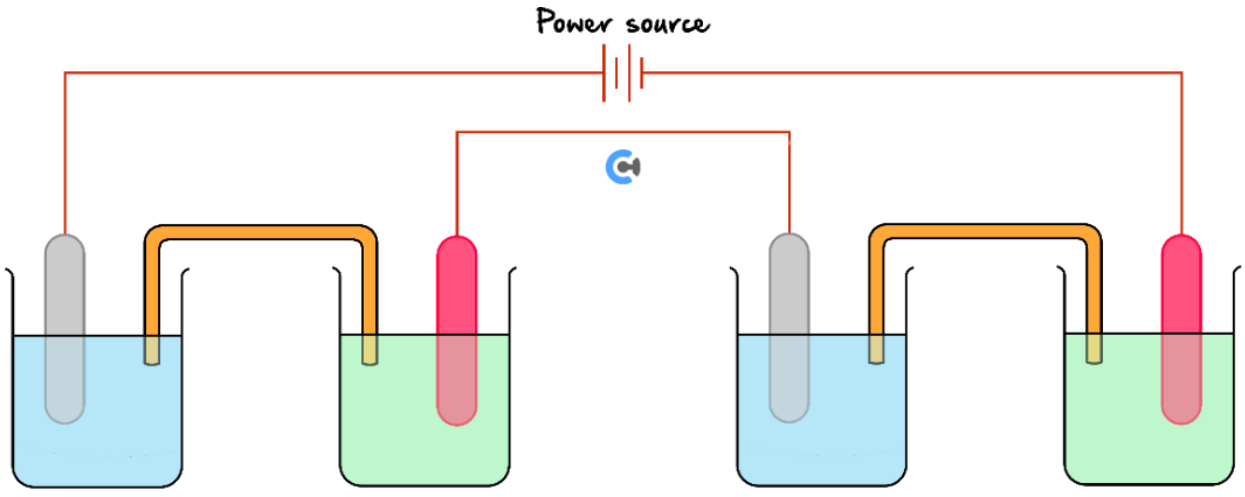
- Reasons for Rechargeability:
  - _____.
  - _____.
- Reasons for decreased battery life:
  - _____.
  - _____.

Learning Objective: [2.3.3] – Find Reactions Occurring in Connected Cells

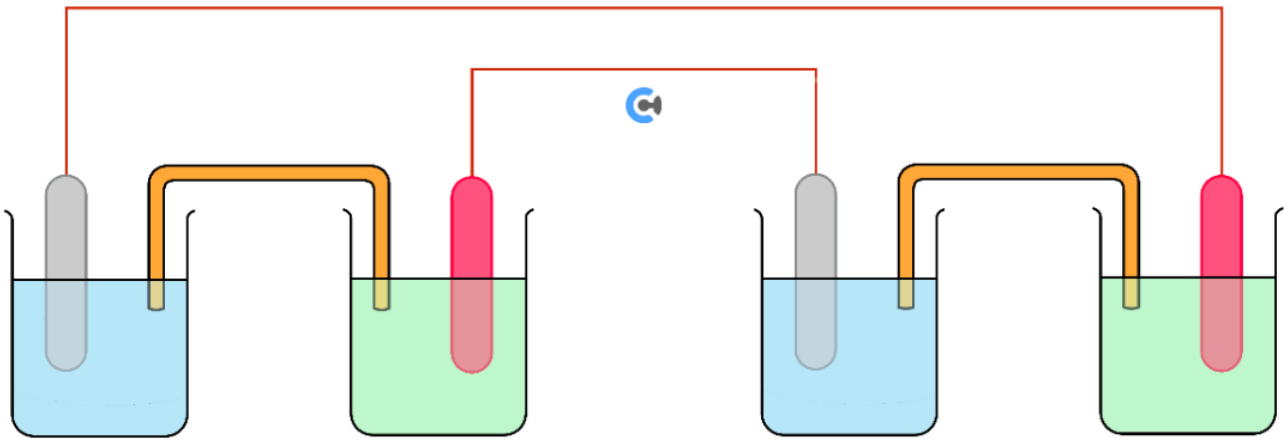
- Connected _____ Cells:



- Connected _____ Cells:



- Connected _____ Cells:



- TIPS:
  - First find: _____.
  - Treat each cell as: _____.

Question 1 Walkthrough.

The electrode reactions which occur when the Nickel-Cadmium battery is producing electrical energy are shown below.

$$NiO_2(s) + 2H_2O(l) + 2e^- \rightarrow Ni(OH)_2(s) + 2OH^-(aq)$$

$$Cd(s) + 2OH^-(aq) \rightarrow Cd(OH)_2 + 2e^-$$

a. Write the balanced half-equation for the reaction which takes place at the negative electrode during discharge.

_____

b. Write the balanced half-equation for the reaction which takes place at the positive electrode during recharge.

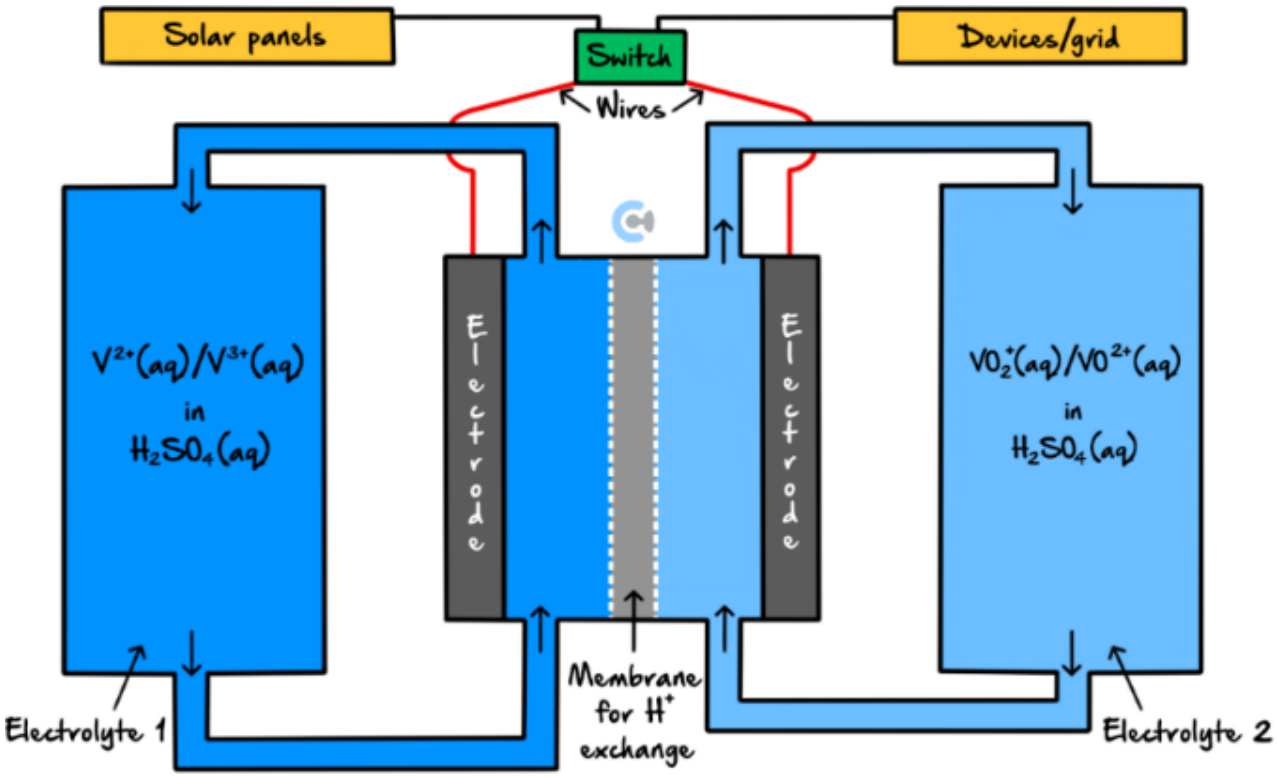
_____

Space for Personal Notes

Question 2 Walkthrough.

An increasingly popular battery for storing energy from solar panels is the vanadium redox battery. The battery takes advantage of the four oxidation states of vanadium that are stable in aqueous acidic solutions.

A schematic diagram of a vanadium redox battery is shown below.



The two relevant half-equations for the vanadium redox battery are:

$$VO_2{}^+(aq) + 2H^+(aq) + e^- \rightleftharpoons VO^{2+}(aq) + H_2O(l) \qquad E° = +1.00\ V$$

$$V^{3+}(aq) + e^- \rightleftharpoons V^{2+}(aq) \qquad E° = -0.26\ V$$

Write the balanced equation for the overall reaction that takes place when the cell is recharged.

_____

_____

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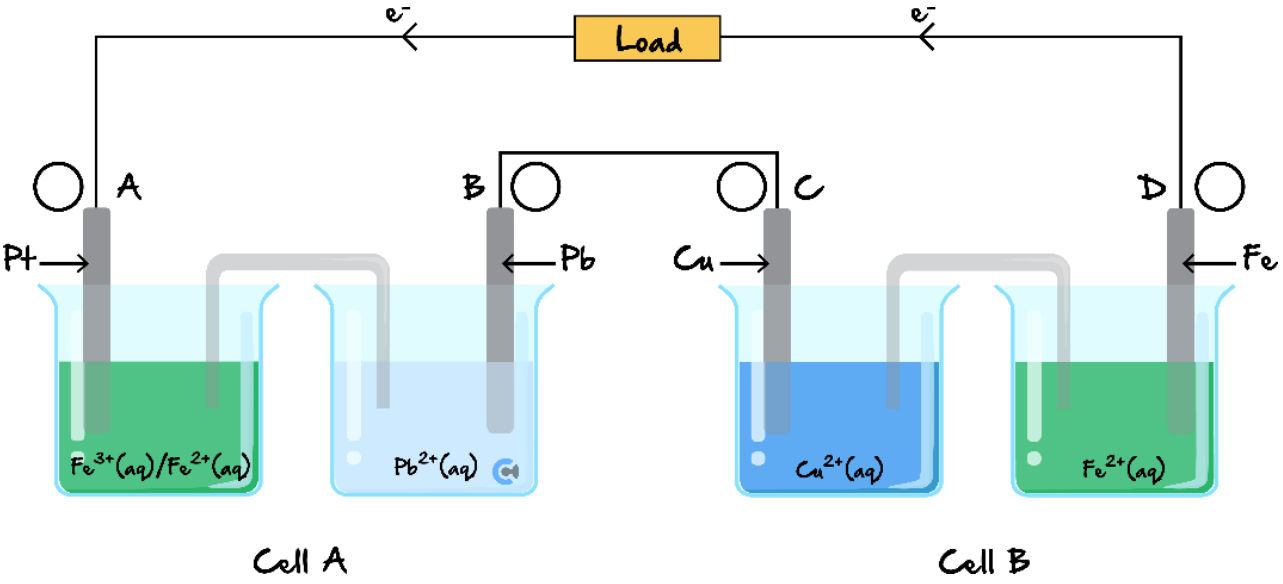
Question 3 (3 marks) **Walkthrough.**

The following connected cell is set up.



a. State whether cell *A* is a galvanic cell or electrolytic cell. (1 mark)

Cell *A*	**Cell *B***

b. Label the polarities of the electrodes in the circles provided above. (1 mark)

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

Electrode *A*: _____

Electrode *B*: _____

Electrode *C*: _____

Electrode *D*: _____

d. Find the overall EMF produced by the cell. (1 mark)

_____

_____

Section B: Warm Up (13 Marks)

INSTRUCTION: 13 Marks. 1 Minute Reading. 8 Minutes Writing.

Question 4 (1 mark)

Rechargeable batteries:

A. Use reversible reactions.

B. Operate as galvanic cells during recharge.

C. Require a continuous flow of reactants to operate.

D. Have fewer side reactions as temperature increases.

Question 5 (2 marks)

Circle what type of reaction takes place at each electrode, and whether it acts as the cathode / anode.

a. During discharge reactions. (1 mark)

Positive electrode	**Negative electrode half-equation**
[reduction] / [oxidation] half-equation.	[reduction] / [oxidation] half-equation.
[cathode] / [anode]	[cathode] / [anode]

b. During recharge reactions. (1 mark)

Positive electrode	**Negative electrode half-equation**
[reduction] / [oxidation] half-equation.	[reduction] / [oxidation] half-equation.
[cathode] / [anode]	[cathode] / [anode]

Space for Personal Notes

Question 6 (4 marks)

The rechargeable lithium-ion cell can be used. When the cell is being used, the electrode reactions are represented by the following equations during **discharge**:

$$CoO_2(s) + Li^+(aq) + e^- \rightarrow LiCoO_2(s)$$

$$LiC_6(s) \rightarrow Li^+(aq) + C_6(s) + e^-$$

a. Write the molecular formula for the oxidant as the cell produces electrical energy. (1 mark)

_____

b. Write the overall reaction which takes place during discharge. (1 mark)

_____

c. Suggest a suitable electrolyte for this cell. (1 mark)

_____

d. Write the balanced half-equation for the reaction which takes place at the negative electrode when the cell is recharging. (1 mark)

_____

Space for Personal Notes

Question 7 (6 marks)

In a lead-acid accumulator, it is known that $Pb(s)$ reacts into $PbSO_4(s)$, and $PbO_2(s)$ reacts into $PbSO_4(s)$ when the battery is discharging.

a. Using oxidation numbers, explain whether the reaction of $PbO_2(s)$ into $PbSO_4(s)$ occurs at the cathode or anode. (1 mark)

_____

_____

b. Given that it uses sulfuric acid as the electrolyte, write the balanced chemical equation for the discharge reaction which takes place at the:

i. Anode. (1 mark)

_____

ii. Cathode. (1 mark)

_____

c. Write the balanced equation for the overall recharge reaction which takes place. (1 mark)

_____

d. State **two** properties of the lead-acid accumulator that make it rechargeable. (2 marks)

_____

_____

_____

_____

Space for Personal Notes

Section C: Ramping Up (9 Marks)

INSTRUCTION: 9 Marks. 1 Minute Reading. 7 Minutes Writing.

Question 8 (1 mark)

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

The following equations relate to the lead acid battery.

$$PbSO_4(s) + 2e^- \rightleftharpoons Pb(s) + SO_4^{2-}(aq) \qquad E^0 = -0.36\,V$$

$$PbO_2(s) + SO_4^{2-}(aq) + 4H^+(aq) + 2e^- \rightleftharpoons PbSO_4(s) + 2H_2O(l) \quad E^0 = +1.69\,V$$

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

A. The concentration of sulfuric acid decreases.

B. $PbSO_4$ is both oxidised and reduced.

C. The mass of metallic lead decreases.

D. PbO_2 is oxidised to Pb.

Question 9 (1 mark)

The discharge reaction in a vanadium redox battery is represented by the following equation:

$$VO_2^+(aq) + 2H^+(aq) + V^{2+}(aq) \rightarrow V^{3+}(aq) + VO^{2+}(aq) + H_2O(l)$$

When the vanadium redox battery is recharging:

A. H^+ is the reducing agent.

B. H_2O is the oxidising agent.

C. VO^{2+} is the reducing agent.

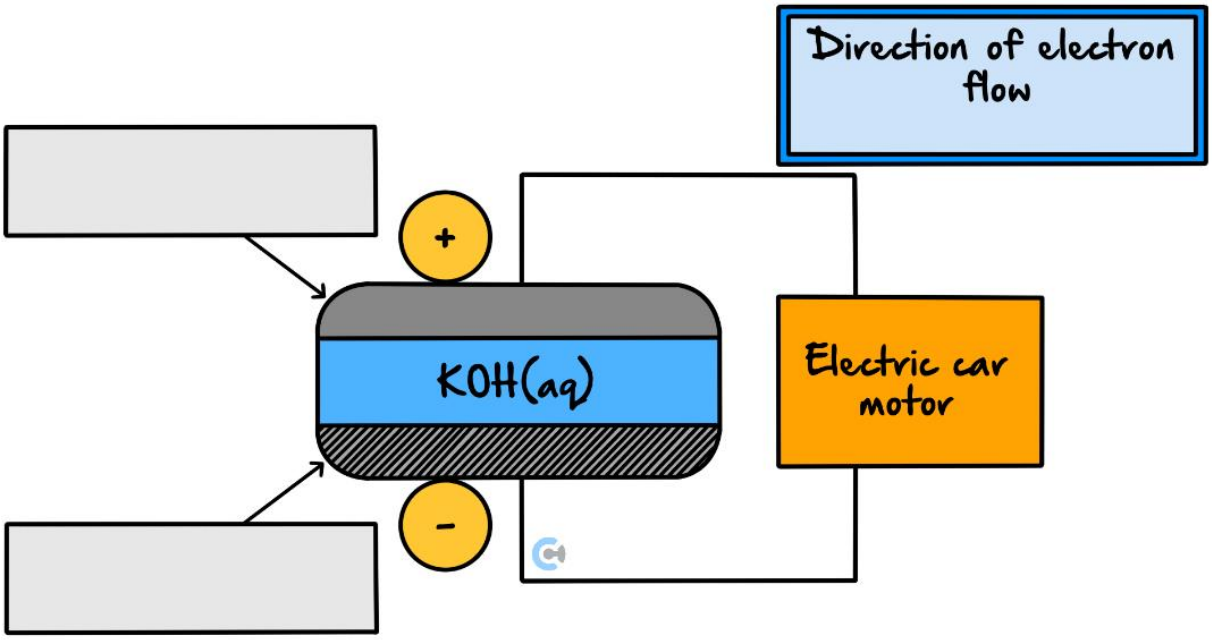
D. VO_2^+ is the oxidising agent.

Space for Personal Notes

Question 10 (3 marks)

Inspired from VCAA Chemistry Exam 2015
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2015/2015chem-w.pdf#page=37

The storage battery to be used in the hybrid cars is comprised of a series of nickel metal hydride, 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:

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

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

_____

_____

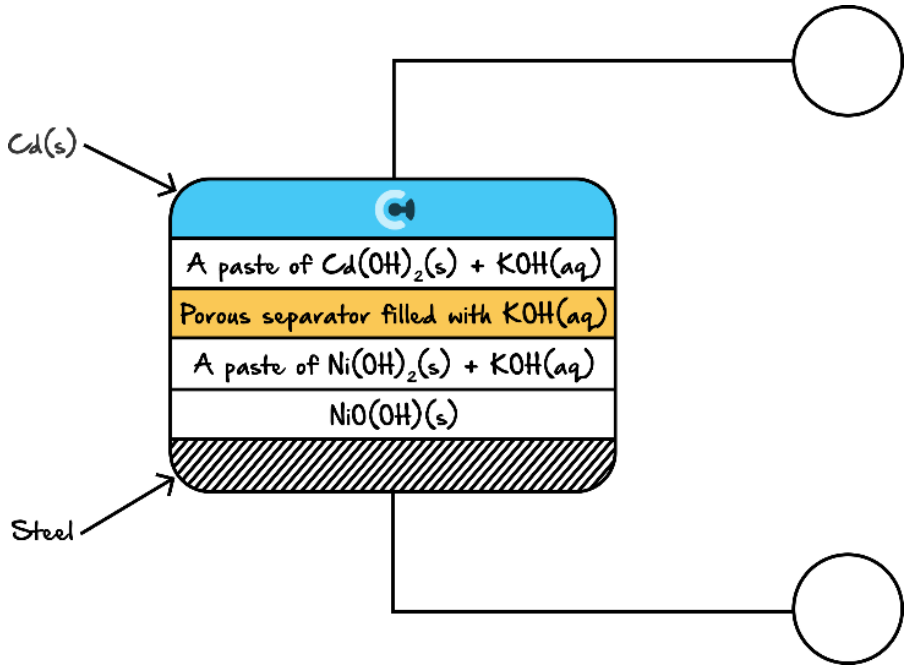
b. In the boxes on the diagram above, indicate which is the MH electrode and which is the NiOOH electrode. (1 mark)

c. 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)

Question 11 (4 marks)

Inspired from VCAA Chemistry Exam 2008
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2008chem2-w.pdf#page=21

A rechargeable galvanic cell, also based on nickel and cadmium (NiCd cell), has been commercially available for a number of years and has been used to power small appliances such as mobile phones.
A simplified diagram of a NiCd cell is given below.



The overall cell reaction for the cell when discharging is:

$$Cd(s) + 2NiO(OH)(s) + 2H_2O(l) \rightarrow Cd(OH)_2(s) + 2Ni(OH)_2(s)$$

a. Identify the positive and the negative electrodes by writing $'+'$ or $'-'$ in the circles provided in the diagram. (1 mark)

b. What feature of this secondary cell enables it to be recharged? (1 mark)

_____

_____

c. Give the equation for the half-reaction that takes place at the negative electrode when the cell is discharging. (1 mark)

_____

_____

d. Give the equation for the half-reaction that takes place at the electrode connected to the negative terminal of the power supply when the cell is recharging. (1 mark)

_____

_____

Space for Personal Notes

Section D: Getting Trickier I (11 Marks)

INSTRUCTION: 11 Marks. 1 Minute Reading. 9 Minutes Writing.

Question 12 (1 mark)

Two types of electrochemical cells are - the primary cell and the secondary cell. Which one of these features is exhibited by only one of these cells?

A. An energy transformation is from chemical energy to electrical energy.

B. The efficiency of the cell is close to 100%.

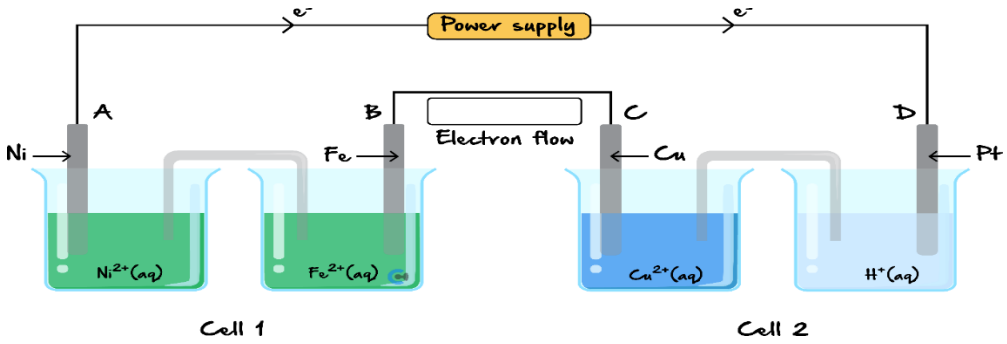
C. Products of the cell reaction remain in contact with the electrodes.

D. A spontaneous redox reaction is the overall reaction of the cell.

Space for Personal Notes

Question 13 (10 marks)

Cells 1 and 2 are connected together to a power supply as depicted in the diagram below.



a. Draw an arrow in the box provided above to indicate the direction of electron flow between electrodes B and C. (1 mark)

b. Cell 2 is to be investigated first.

i. State whether electrodes C and D in cell 2 are a cathode / anode, including the polarity of the electrodes. (1 mark)

Electrode *C*	**Electrode *D***

ii. Write the balanced half-equation for the reaction which takes place at electrode C. (1 mark)

_____

iii. As the cell reacts, state two observations which can be made at electrode D, and explain why they come about. (2 marks)

_____

_____

_____

_____

iv. Find the EMF across cell 2. (1 mark)

_____

For cell 1, both electrolytes are equally green at the beginning.

c. Write the balanced half-equations for the reaction which occurs at:

i. Electrode *A*. (1 mark)

_____

ii. Electrode *B*. (1 mark)

_____

d. Hence or otherwise, explain whether the electrolyte in electrode *A* or *B* will have a greater green intensity after the cell has operated for 2.00 *min*. (1 mark)

_____

_____

e. In order for the whole cell to operate, find the voltage that needs to be inputted into the cell. (1 mark)

_____

Space for Personal Notes

Section E: Getting Trickier II (8 Marks)

INSTRUCTION: 8 Marks. 1 Minute Reading. 7 Minutes Writing.

Question 14 (1 mark)

The silver oxide-zinc battery is rechargeable and utilises sodium hydroxide, NaOH, solution as the electrolyte. The battery is used as a backup in spacecraft if the primary energy supply fails. The overall reaction during discharge is:

$$Zn + Ag_2O \rightarrow ZnO + 2Ag$$

When the silver oxide-zinc battery is being recharged, the reaction at the anode is:

A. $2Ag + 2OH^- \rightarrow Ag_2O + H_2O + 2e^-$

B. $Ag_2O + H_2O + 2e^- \rightarrow 2Ag + 2OH^-$

C. $ZnO + H_2O + 2e^- \rightarrow Zn + 2OH^-$

D. $Zn + 2OH^- \rightarrow ZnO + H_2O + 2e^-$

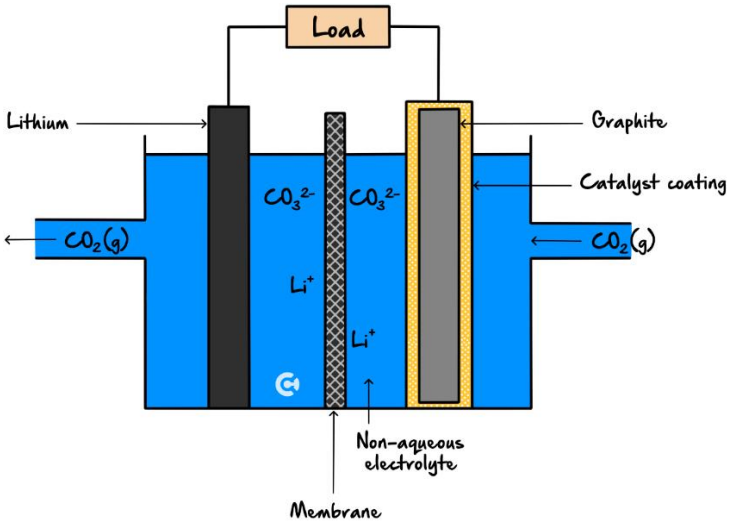
Space for Personal Notes

Question 15 (7 marks)

Inspired by VCAA Chemistry 2020 Exam
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2020/2020chem-w.pdf#page=22

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)

_____

_____

_____

_____

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)

Let's take a BREAK!

Space for Personal Notes

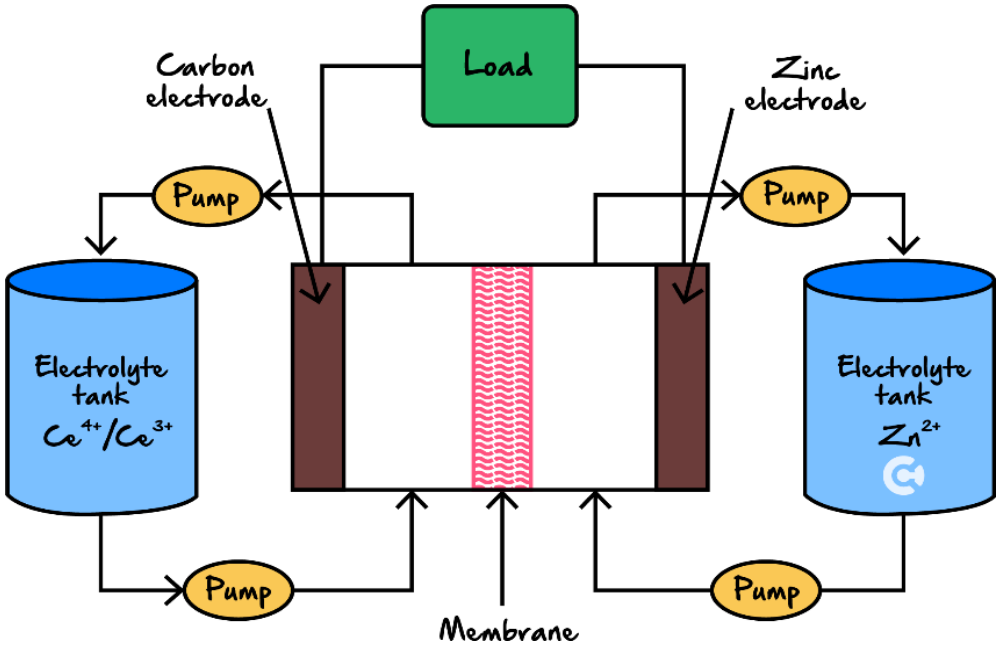
Section F: VCAA-Level Questions I (8 Marks)

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

Question 16 (8 marks)

Inspired by VCAA Chemistry 2019 Exam
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2019/2019chem-w.pdf#page=30

The zinc–cerium battery is a commercial rechargeable battery that comprises a series of cells. During recharging, the cells use energy from wind farms or solar cell panels. During discharging, energy is supplied to electric grids to power local factories and homes. The electrolytes are stored in separate storage tanks and are pumped into and out of each cell when in use. A membrane separates the two electrodes that are immersed in 1 M methanesulfonic acid, CH_3SO_3H. A diagram representing a zinc–cerium cell is shown below.



The following half-cell reactions occur in the zinc–cerium cell.

$$Zn(CH_3SO_3)_2(aq) + 2H^+(aq) + 2e^- \rightleftharpoons Zn(s) + 2CH_3SO_3H(aq) \qquad E^0 = -0.76\,V$$

$$Ce(CH_3SO_3)_4(aq) + H^+(aq) + e^- \rightleftharpoons Ce(CH_3SO_3)_3(aq) + CH_3SO_3H(aq) \qquad E^0 = 1.64\,V$$

a. Write the equation for the overall discharge reaction. (1 mark)

_____

_____

b. Identify the oxidising agent during discharging and justify your answer using oxidation numbers. (2 marks)

_____

_____

_____

c. Determine the theoretical voltage produced by a single cell as it discharges. (1 mark)

_____

_____

d. Write the ionic equation for the reaction occurring at the positive electrode during recharging. (1 mark)

_____

e. Other than transporting ions between the electrodes, describe one function of the membrane in the zinc–cerium cell. (1 mark)

_____

_____

f. Specify one factor that would limit the life of the zinc–cerium cell. (1 mark)

_____

g. Experts have regarded the zinc–cerium cell as a hybrid of a fuel cell and a secondary cell. Why would this be the case? (1 mark)

_____

_____

Space for Personal Notes

Section G: Multiple Choice Questions (6 Marks)

INSTRUCTION: 6 Marks. 1 Minute Reading. 6 Minutes Writing.

Question 17 (2 marks)

The overall discharge reaction for a lead-acid battery is:

$$Pb(s) + PbO_2(s) + 2H_2SO_4(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$$

a. During recharge, the reaction at the cathode is: (1 mark)

A. $Pb(s) + SO_4^{2-}(aq) \rightarrow PbSO_4(s) + 2e^-$

B. $PbSO_4(s) + 2e^- \rightarrow Pb(s) + SO_4^{2-}(aq)$

C. $PbO_2(s) + SO_4^{2-}(aq) + 4H^+ + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$

D. $PbSO_4(s) + 2H_2O(l) \rightarrow PbO_2(s) + SO_4^{2-}(aq) + 4H^+(aq) + 2e^-$

b. When the lead-acid battery is discharging, the oxidising agent is: (1 mark)

A. Pb

B. PbO_2

C. $PbSO_4$

D. H_2SO_4

Space for Personal Notes

Question 18 (1 mark)

Inspired by VCAA Chemistry 2023 Exam
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2023/NHT/2023chem-nht-w.pdf#page=6

Consider the following statements:

I. The half-cells must be separated for this cell to operate.
II. This cell requires reactants.
III. The anode in this cell is always negative.

Which one of the following combinations of statements applies to secondary cells and fuel cells?

	Secondary cells	Fuel cells
A.	I and II only	I, II and III
B.	I and II only	II and III only
C.	I and III only	I, II and III only
D.	I and III only	II and III only

Question 19 (1 mark)

Below are the half-equations for the lead-acid accumulator cell. The lead-acid accumulator cell can operate as an electrolytic cell.

$$PbSO_4(s) + H^+(aq) + 2e^- \rightarrow Pb(s) + HSO_4^-(aq) \qquad E^0 = -0.36\ V$$

$$PbO_2(s) + HSO_4^-(aq) + 3H^+(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l) \qquad E^0 = 1.69\ V$$

Which one of the following correctly describes the lead-acid accumulator cell when it is operating as a galvanic cell and when it is operating as an electrolytic cell?

	Galvanic cell	Electrolytic cell
A.	H^+ ions react at the cathode.	HSO_4^- ions react at both electrodes.
B.	H^+ ions react at the anode.	HSO_4^- ions react at both electrodes.
C.	H^+ ions react at the cathode.	HSO_4^- ions are produced at both electrodes.
D.	H^+ ions react at the anode.	HSO_4^- ions are produced at both electrodes.

Question 20 (1 mark)

Lithium-ion rechargeable batteries are used in mobile phones. Environmental conditions can affect the number of charge cycles for a lithium-ion battery until the end of its useful life.

Which of the following environmental conditions would result in the largest number of charge cycles for a lithium-ion battery?

	Minimum temperature (°C)	**Maximum temperature (°C)**
A.	−8	11
B.	9	21
C.	18	37
D.	28	40

Question 21 (1 mark)

Inspired by VCAA Chemistry 2017 Exam
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2017/nht/2017chem-nht-w.pdf#page=14

Primary cells, secondary cells, and fuel cells can all be used as sources of energy.
The features that can be associated with one or more of the three types of cells include the following:

1. The cell is rechargeable.

2. The cell requires a continuous supply of reactants.

3. Reduction takes place at the cathode when discharging.

4. Oxidation takes place at the positive electrode when recharging.

Which of the above features are displayed by secondary cells?

A. 1,2 and 3

B. 2, 3 and 4

C. 1, 3 and 4

D. 1, 2, 3 and 4

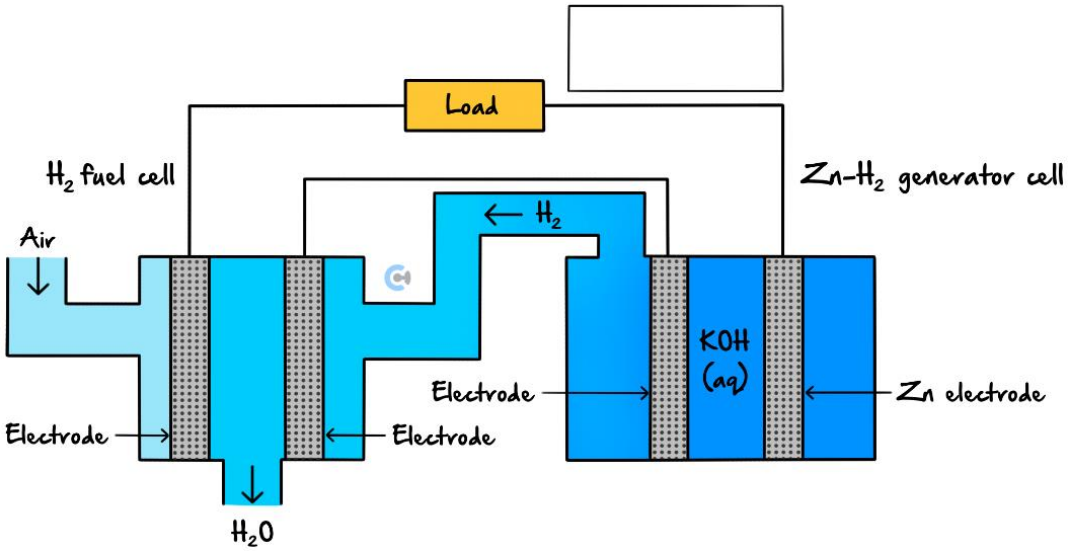
Section H: VCAA-Level Questions II (9 Marks)

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

Question 22 (9 marks)

Inspired from VCAA Chemistry NHT Exam 2021
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2021/NHT/2021chem-nht-w.pdf#page=26

Researchers have investigated generating hydrogen, H_2, gas for hydrogen fuel cells by reacting zinc, Zn, and water, H_2O, in an electrochemical cell in series with an H_2 fuel cell. The diagram below represents an alkaline H_2 fuel cell in series with a Zn– H_2 generator cell.



The reactions that occur at each electrode in the Zn– H_2 generator cells are given below.

$$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$$
$$Zn(s) + 2OH^-(aq) \rightarrow ZnO(s) + H_2O(l) + 2e^-$$

a. Write the overall reaction to the production of H_2 gas in the Zn– H_2 generator cell. (1 mark)

_____

_____

b. Write the half-equation that occurs at the anode of the alkaline H_2 fuel cell. (1 mark)

_____

_____

c. In the box provided in the diagram above, draw an arrow to show the direction of the flow of electrons. (1 mark)

d. In terms of H_2 gas flow and electron flow, explain why it is theoretically possible to connect the H_2 fuel cell in series with the Zn– H_2 generator cell. (2 marks)

e. Explain why the Zn– H_2 generator cell must be well-sealed to prevent contact with the atmosphere in order to produce H_2. Include any relevant equations in your answer. (2 marks)

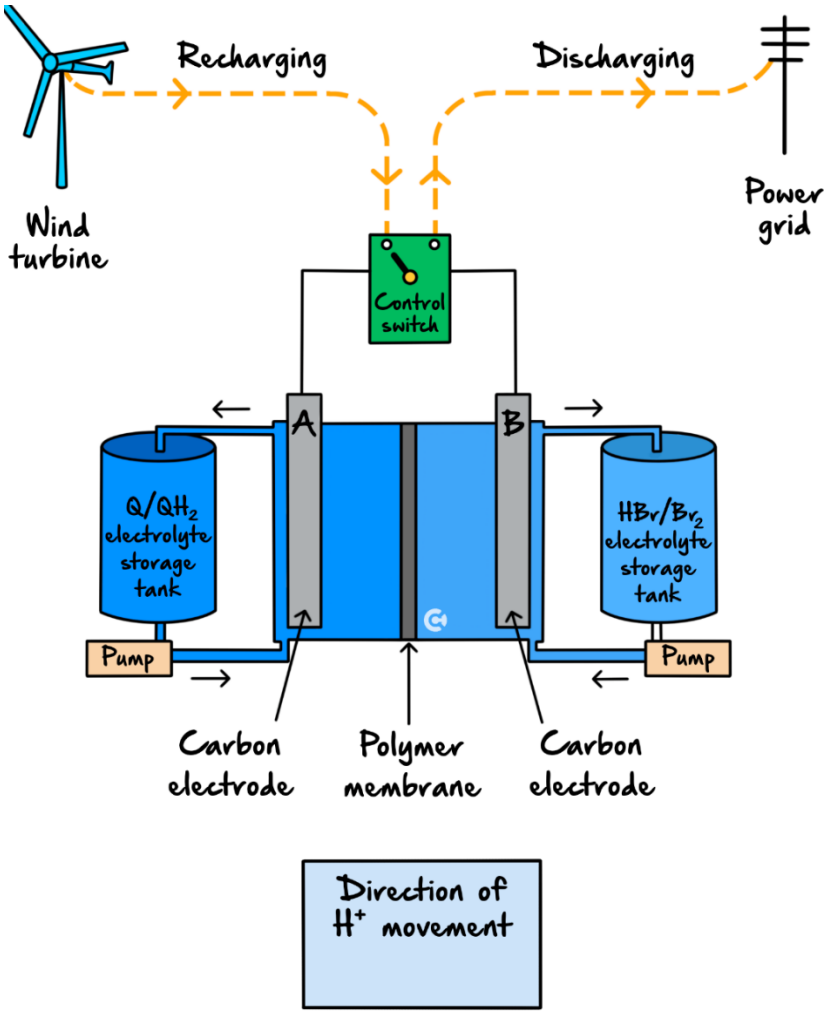
f. Assuming the system is 100% efficient, describe all of the energy conversions that occur in a combined Zn– H_2 generator cell and H_2 fuel cell system. (2 marks)

Space for Personal Notes

Section I: Extension Questions (14 Marks)

Question 23 (7 marks)

Redox flow batteries are used to store the excess electrical energy generated by commercial wind and solar farms. The batteries are recharged using electricity generated by wind turbines or solar cells. A scientific report, published in January 2014, described a redox flow battery that used a family of chemicals commonly occurring in plants such as rhubarb. These are organic and are known as quinones and hydroquinones. A diagram showing how such a redox flow battery might operate is provided below. In the diagram, Q represents the quinone and QH_2 represents the corresponding hydroquinone. The researchers made a model of the redox flow battery using aqueous solutions of the redox pairs, Q / QH_2 and Br_2 / Br^-. Refer to the diagram below.



During discharge, QH_2 is converted to Q and Br_2 is converted to HBr.

a. Write balanced half-equations for the reactions occurring at the positive and negative electrodes as the cell is **discharged**. Assume the electrolytes are acidic. (2 marks)

Positive electrode: _____

Negative electrode: _____

b. Write an overall equation for the reaction that occurs when the cell is **recharged**. (1 mark)

_____

_____

_____

c. The researchers reported that their tests indicated that only hydrogen ions were able to move through the polymer membrane separating the cells.

i. In the box provided on the diagram, use an arrow, → or ←, to indicate the direction of movement of hydrogen ions as the cell is **recharged**. (1 mark)

ii. Why is it important that the other reactants in the half-cells are not able to pass through the polymer? (1 mark)

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d. The researchers also reported that the voltage applied to the cell during recharging was kept below 1.5 V to avoid the electrolysis of water.

Write an equation for the overall reaction that occurs when water is electrolysed. (1 mark)

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e. Quinones have a number of industrial applications and are cheaply synthesised on a large scale from anthracene, which is found in crude oil. The report's researchers suggest that because these compounds also exist in plants such as rhubarb, the electrolyte material is itself a renewable resource.

What is meant by the term 'renewable' in this context? (1 mark)

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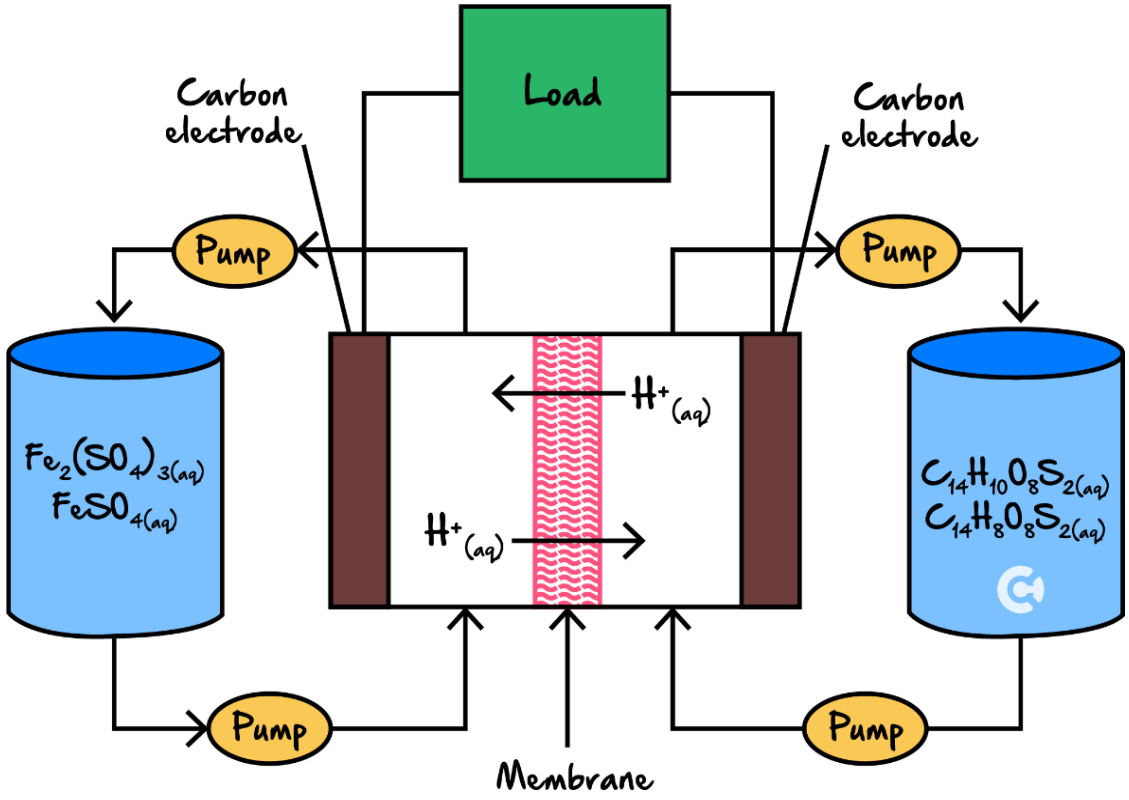
Question 24 (7 marks)

Scientists are currently researching an experimental secondary cell.

The following reaction takes place in the experimental cell during discharge.

$$Fe_2(SO_4)_3(aq) + C_{14}H_{10}O_8S_2(aq) \rightarrow 2FeSO_4(aq) + C_{14}H_8O_8S_2(aq) + HSO_4^-(aq) + H^+(aq)$$

A diagram of the experimental cell is shown below.



a. State the energy transformations that occur in the experimental cell during discharge. (1 mark)

_____

b. Which reactant is the oxidising agent in the experimental cell during discharge? Use oxidation numbers to justify your answer. (2 marks)

_____

_____

_____

_____

c.

i. Write the half-equation for the reaction that occurs in the $C_{14}H_8O_8S_2$ / $C_{14}H_{10}O_8S_2$ half-cell during recharge. (1 mark)

_____

ii. State the polarity of the $C_{14}H_8O_8S_2$ / $C_{14}H_{10}O_8S_2$ half-cell electrode during recharge. (1 mark)

_____

iii. Explain how the polarity of the electrodes is established during recharge to allow the recharge to occur. (2 marks)

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