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VCE Chemistry ¾

Secondary Cells & Connected Cells [2.3]

Test Solutions

20 Marks. 1 Minute Reading. 17 Minutes Writing.

Results:

Test Questions	_____ / 15
Extension Questions	_____ / 5

Section A: Test Questions (15 Marks)

Question 1 (4 marks)

Tick whether the following statements are **true** or **false**.

Statement	True	False
a. Secondary cells differ from primary cells in that they do not involve spontaneous reactions.		✓
b. When batteries are recharged, the anode has a positive polarity.	✓	
c. The reason secondary cells can be recharged is because they can be connected to a power source and electrolysed to reverse the reaction(s).		✓
d. Battery life can be improved by ensuring that the cell reactions occur at high temperatures.		✓
e. The reason the majority of reactants and products in a lead-acid accumulator are in the solid state is so that the cell can be recharged effectively.	✓	
f. The half-equation occurring at the positive electrode during discharge is the same as the half-equation occurring at the negative electrode during recharge.		✓
g. A redox flow battery is essentially a rechargeable fuel cell.	✓	
h. When two galvanic cells are connected in series, there is typically a power source powering the circuit.		✓

Space for Personal Notes

Question 2 (6 marks)

The following overall reaction takes place during the **recharge** of an alkaline zinc-manganese battery:

$$ZnO(s) + MnO(s) \rightarrow Zn(s) + MnO_2(s)$$

a.

i. Write the half-equation occurring at the negative electrode as the cell **generates** energy. (1 mark)

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

ii. Write the anode half-equation during **recharge**. (1 mark)

$$MnO(s) + 2OH^-(aq) \rightarrow MnO_2(s) + H_2O(l) + 2e^-$$

b. This battery makes use of a zinc electrode and a carbon electrode. Explain how these electrodes function during both discharge and recharge, in terms of their polarities as well as the types of equations (reduction or oxidation) occurring at each electrode. (3 marks)

The zinc electrode acts as the **negative anode** during **discharge** whereas the **carbon** electrode acts as the **positive cathode** during **discharge (1).**
During recharge, **the location of the anode and cathode swap, but the polarities remain the same (2).**
So, the **anode** is now the **carbon electrode, which is positive,** whereas the **cathode** is now the zinc **electrode, which is negative (3).**

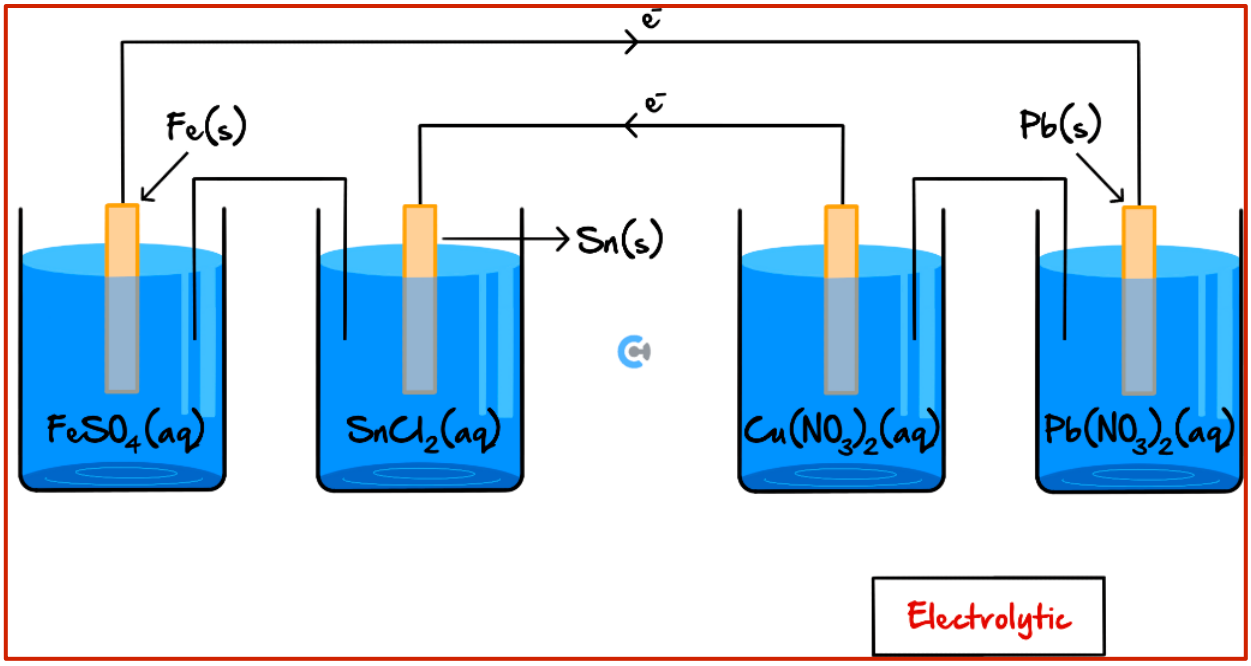
c. Propose one way in which the number of discharge-recharge cycles can be maximised for this battery. (1 mark)

Store it at low temperatures OR do not overcharge it so as to prevent overheating/side reactions.

Question 3 (5 marks)

Charmaine connects the following beakers and observes what occurs over a period of time.

For **part a.** and **part b.** of this question, assume the cell is functional. That is, ignore the E^0 values of the reactions.



a. In the diagram above, label the right cell as either galvanic or electrolytic based on the type of reaction(s) that would be observed. (1 mark)

b. Outline **two** colour changes that would be observed in the electrolytes present in the set-up above. (2 marks)

1. The electrolyte in the anode of the left/galvanic cell (first beaker) will become more green due to the production of $Fe^{2+}(aq)$.

2. The electrolyte in the anode of the right/electrolytic cell (third beaker) will become more blue due to the production of $Cu^{2+}(aq)$.

c. In reality, however, Charmaine notices that no colour changes occur whatsoever when she sets up the cells above exactly as shown, at SLC and 1.0 M concentrations.

However, when she connects the electrolytic cell to a 12 V power supply instead of to the galvanic cell, she indeed notices the two colour changes outlined in **part b.** Justify the two realisations above. (2 marks)

The electrolytic cell needs $> 0.47\ V$ to operate, whereas the galvanic cell will only produce 0.30 V, so the cell is not viable and will not work as intended (1). But when connected to a power supply which can supply $> 0.47\ V$ (happens to be 12 V in this case), the colour changes will occur (2).

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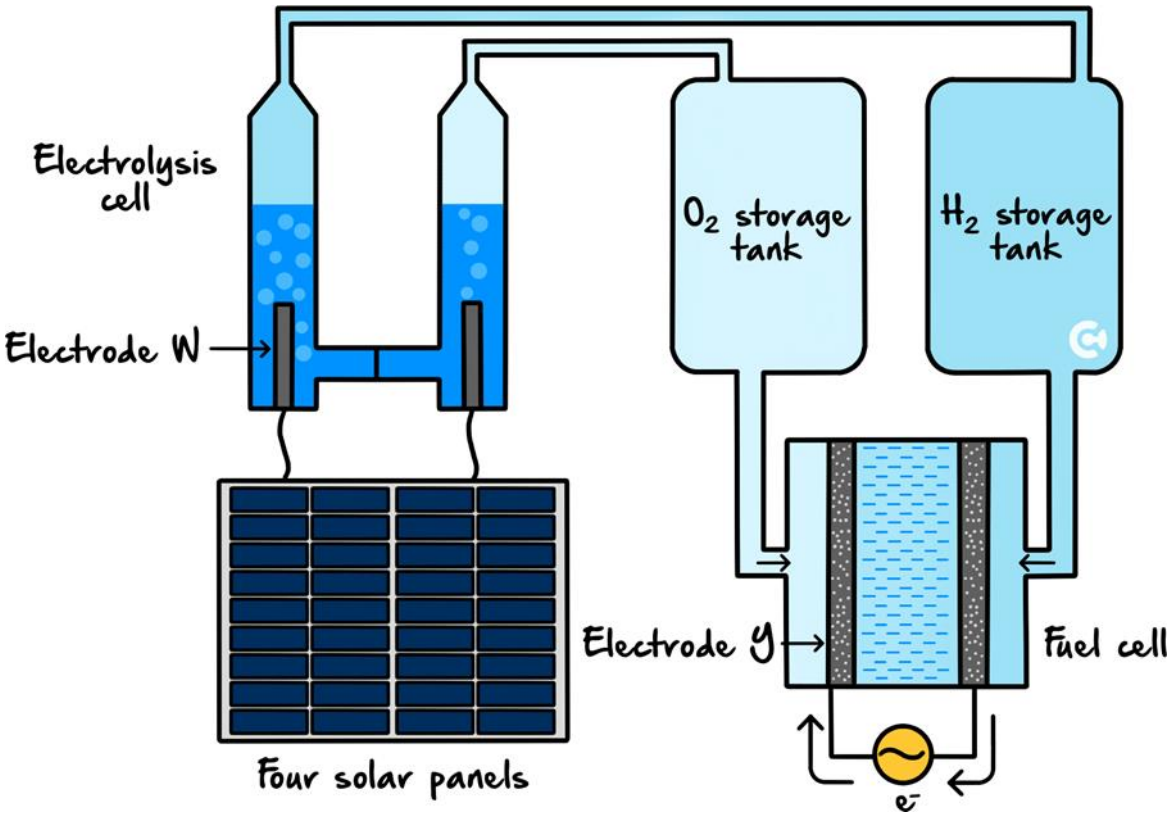
Section B: Extension Questions (5 Marks)

Question 4 (5 marks)

The following connected cell is being investigated in recent times due to its numerous environmental benefits to society. A schematic is shown below, where the liquid inside the electrolysis cell is water.



a.

i. Write the half-equation at Electrode *W* in the electrolysis cell. (1 mark)

$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$
(As hydrogen gas must be produced due to the connectivity of the cell.)

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

Negative (reduction from **part a.i.** occurs at cathode, which is negative in electrolysis).

b. State the polarity of Electrode *Y* in the fuel cell. Justify your answer. (1 mark)

Positive. It acts as the cathode due to the reduction of $O_2(g)$ in the fuel cell/electron flow in the external circuit is always anode to cathode, and the cathode is positive in galvanic cells.

c. If there were no side reactions or external factors impacting this cell, explain whether or not it would be able to operate indefinitely. (2 marks)

No. Although the electrolytic overall reaction is $2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$, and the fuel cell overall equation is the reverse, it is not a **rechargeable** cell (1) because the water produced in the fuel cell is not supplied to the electrolytic cell; the entire cell will be rendered inactive the moment the **stored** water in the electrolytic cell runs out. (2)

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