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VCE Chemistry ¾
Features of Electrolytic Cells [2.2]
Homework

Admin Info & Homework Outline:

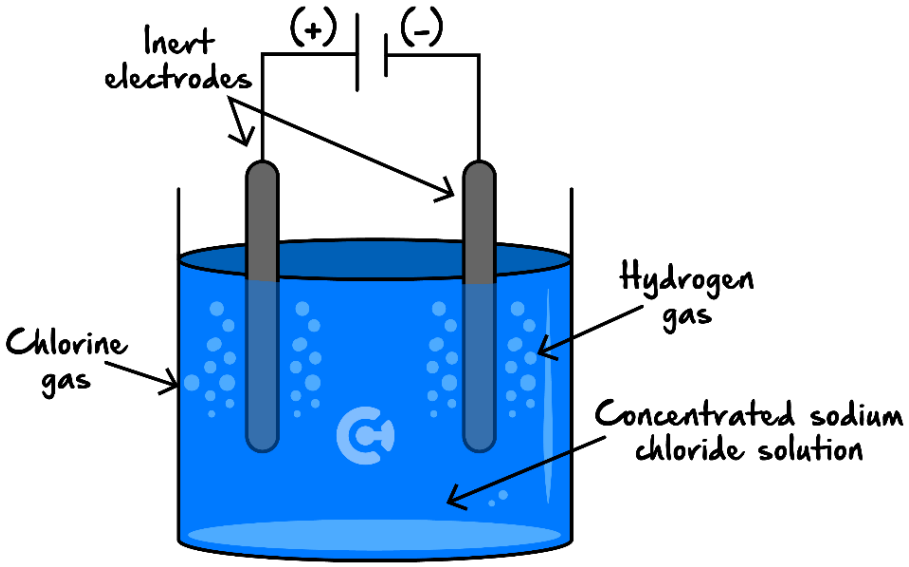
Student Name	
Questions You Need Help For	
Compulsory Questions	Pg 2 – Pg 11
Supplementary Questions	Pg 12 – Pg 23

Section A: Compulsory Questions (46 Marks)

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

Question 1 (5 marks)

An electrolytic cell containing a concentrated solution of sodium chloride is being electrolysed. A diagram of the cell is shown below.



a. Write the reaction occurring at the:

i. Positive Electrode. (1 mark)

_____

ii. Negative Electrode. (1 mark)

_____

b. What is the required voltage for the cell to operate? (1 mark)

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c. Explain the change in pH, if any, that is observed in the cell. (2 marks)

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Question 2 (3 marks)

Consider an electrolytic cell that involves molten magnesium bromide using a copper cathode and a graphite anode.

a. Write the half-equation for the reduction reaction. (1 mark)

_____

b. Write the half-equation for the oxidation reaction. (1 mark)

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c. State whether or not you would observe an increase in size at an electrode. (1 mark)

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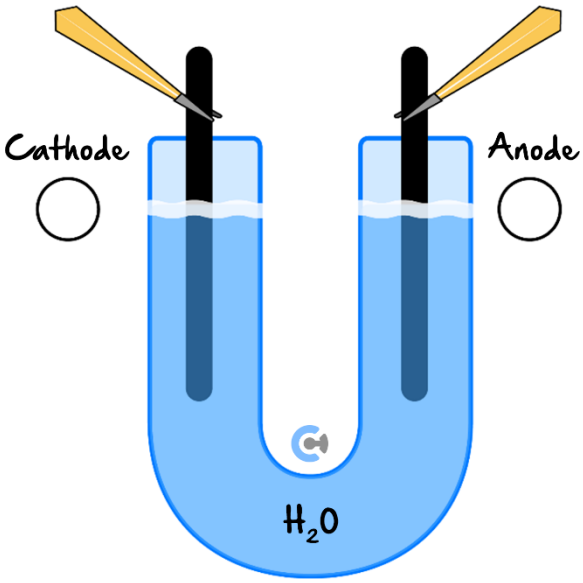
Question 3 (4 marks)

An electrolytic cell that electrolyses deionised water is shown below.



a. Label the polarity of the cathode and anode in the circles above. (1 mark)

b. Write the balanced half-equation for the reaction occurring at the anode. (1 mark)

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c. If some amounts of iron were found to be deposited at the cathode, suggest a reason why this might've been the case. (2 marks)

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

Question 4 (2 marks)

Explain why we would rather have totally inert electrodes rather than an electrode that changes in size for an electrolytic cell.

Question 5 (3 marks)

Aluminium is an important metal that can be extracted from aluminium oxide (Al_2O_3), which is found in the ore bauxite.
Explain how aluminium can be produced from aluminium oxide in an electrolytic cell and describe how cryolite (Na_3AlF_6) helps with this process.

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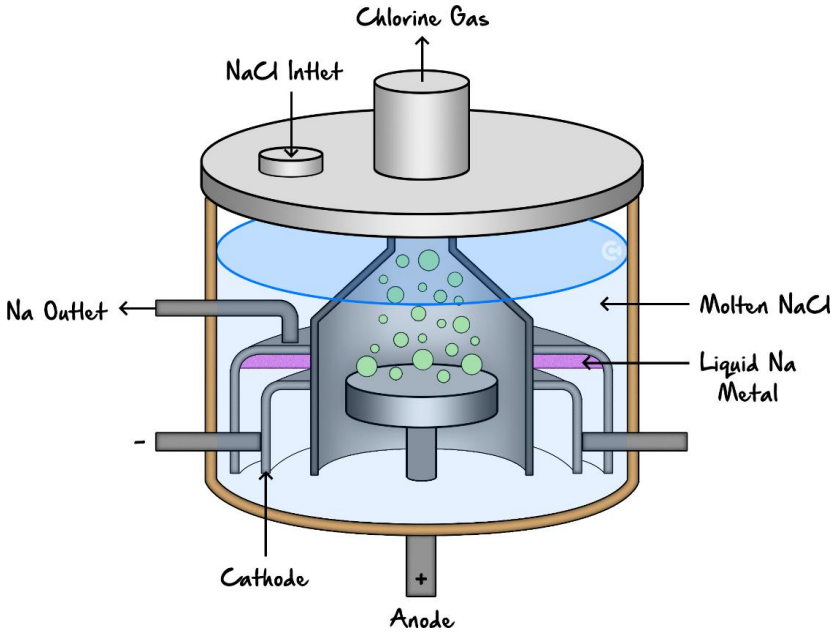
Question 6 (6 marks)

Consider the following cell that aims to produce pure sodium.



a. What is the overall reaction occurring here? (1 mark)

_____

b. $CaCO_3$ is sometimes added to make the cell more economically efficient. Explain how $CaCO_3$ does this. (2 marks)

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c. Generally, graphite electrodes are used in this cell. However, iron electrodes are cheaper and hence preferred. Would using iron electrodes at specific electrodes affect the final reaction that occurs in this cell? (3 marks)

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

Question 7 (2 marks)

Explain a similarity and a difference with the usage of a PEM Electrolyser against an Artificial Photosynthesis Cell.

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Question 8 (4 marks)

Artificial photosynthesis is a relatively new method to produce hydrogen gas on large scale.

a. During artificial photosynthesis, water is split into hydrogen and oxygen. Write the half-equations for both the oxidation and reduction reactions involved. (2 marks)

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b. Explain whether artificial photosynthesis relates to the green chemistry principle of "design for energy efficiency". (2 marks)

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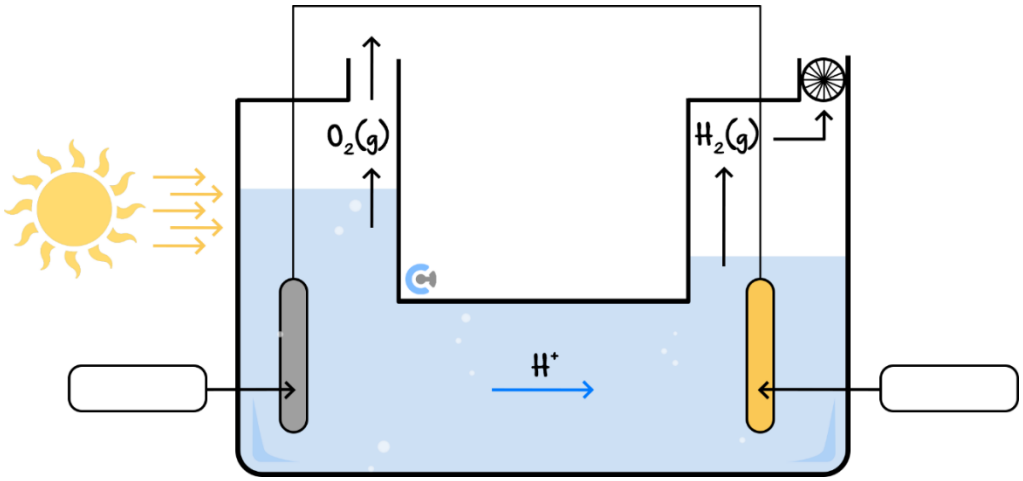
Question 9 (6 marks)

Photoelectrochemical cells leverage the intricate interplay of light absorption and semiconductor behaviour to produce energy. A diagram of one such cell is shown below.



a.

i. Write the overall balanced equation of the cell. (1 mark)

_____

ii. Hence, label the anode and the cathode in the boxes provided above. (1 mark)

_____

b. Compare the efficiency of this cell to a typical simple electrolytic cell. (2 marks)

_____

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c. Explain which green chemistry principle this cell would relate to. (2 marks)

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Sub-Section: Final Boss

Question 10 (11 marks)

Hydrogen gas is a very innovative material that can be obtained through various processes that you have learned such as electrolytic cells, PEM electrolysers and artificial photosynthesis.

a. Hydrogen gas is much more dangerous than other flammable gases such as methane. Explain why. (2 marks)

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b. When hydrogen is stored, it is suspended in a liquid. How does this benefit its transit? Explain how we can store it in this way. (2 marks)

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c. PEM Electrolysers are compared to other methods of obtaining hydrogen gas.

i. Identify **two** advantages of a PEM electrolyser over the electrolysis of water. Justify your answer. (2 marks)

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ii. Compare its renewability of a PEM electrolyser compared to steam reforming to produce hydrogen gas. (2 marks)

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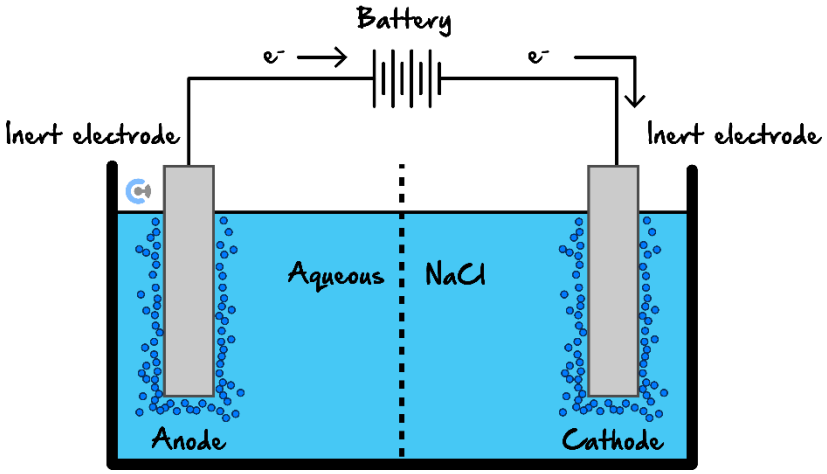
d. Another method to obtain hydrogen gas is through the electrolysis of 4.0 *M* sodium chloride. The cell is shown below.



i. Write formula for the expected products at both electrodes. (1 mark)

_____

_____

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ii. Electrolysis through this method involves a membrane in the middle of the electrolyte. List **two** purposes of this membrane. (2 marks)

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Section B: Supplementary Questions (47 Marks)

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

Question 11 (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)

_____

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Question 12 (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)

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Question 13 (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. $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

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Question 14 (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)

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

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

Question 15 (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.

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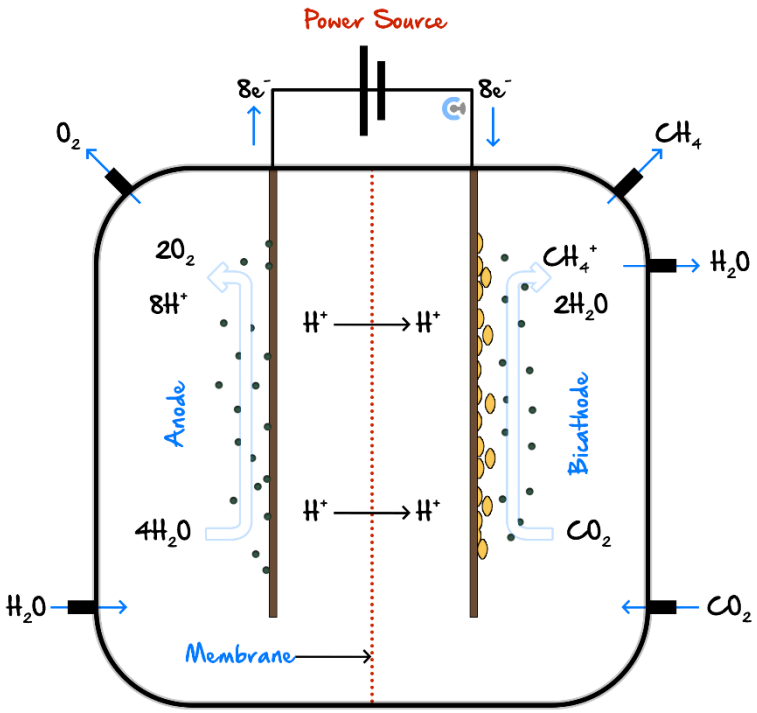
Question 16 (3 marks)

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)

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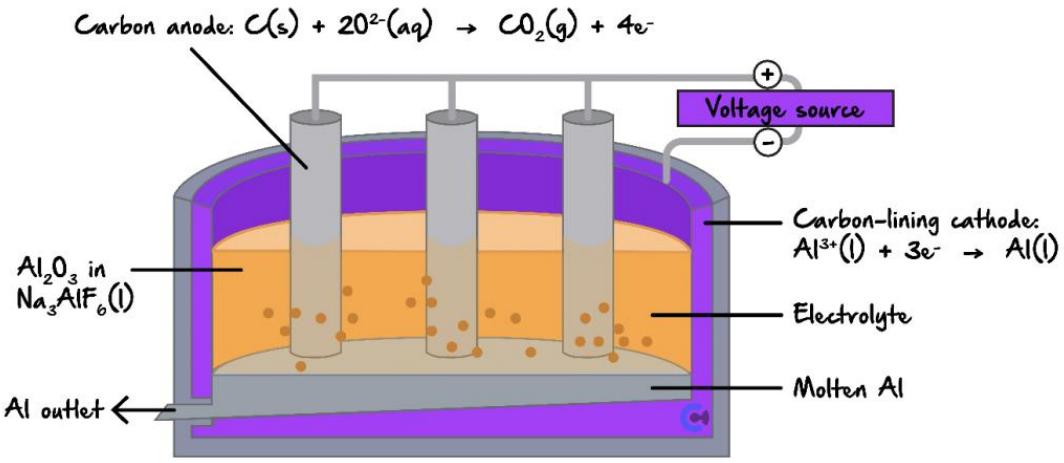
Question 17 (5 marks)

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)

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

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

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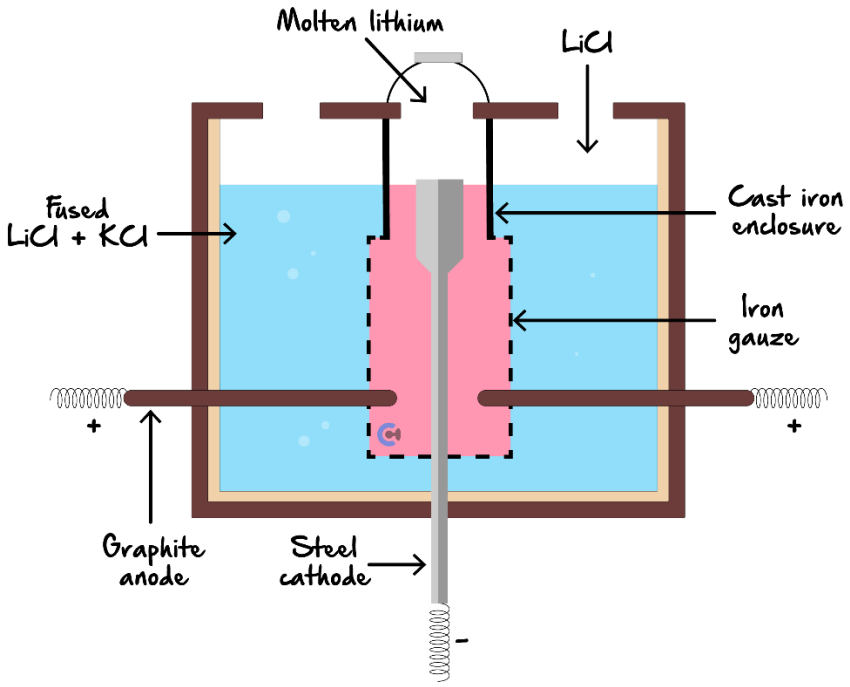
Question 18 (7 marks)

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)

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

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

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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 19 (2 marks)

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

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Question 20 (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)

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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)

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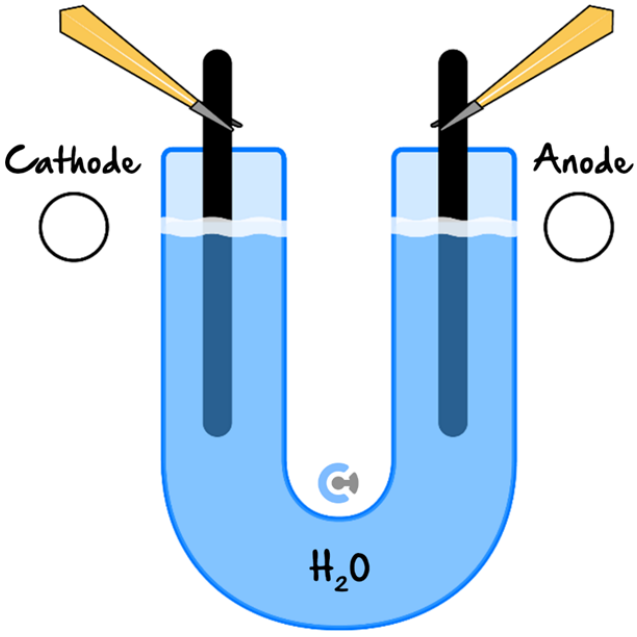
Question 21 (3 marks)

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

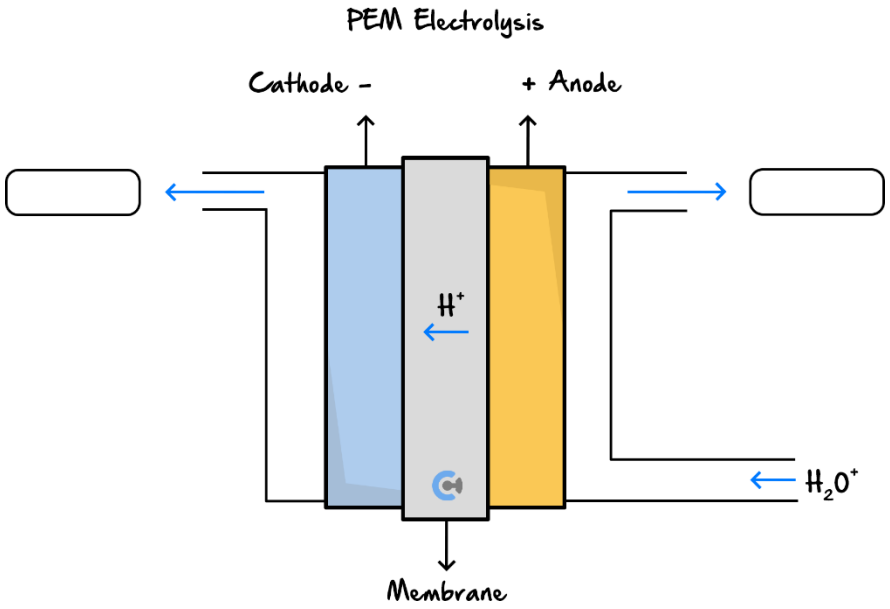
Question 22 (7 marks)

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)

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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)

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