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VCE Chemistry ¾
Fuel Cells [1.9]
Homework

Homework Outline:

Compulsory Questions	Pg 2 – Pg 13
Supplementary Questions	Pg 14 – Pg 25

Section A: Compulsory Questions (50 Marks)

Sub-Section [1.9.1]: Write Fuel Cell Half & Overall Reactions in Acidic Conditions

Question 1 (2 marks)

Write the oxidation reactions of the following, remembering to include states.

a. Methane. (1 mark)

_____

b. Ethanol. (1 mark)

_____

Question 2 (2 marks)

Write the oxidation reaction for the biodiesel, $C_{15}H_{29}COOCH_3$.

_____

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Question 3 (5 marks)

Write the half-equation for the fuel cell reaction involving propan -1- ol and oxygen gas.

a. Reduction half-equation. (2 marks)

_____

b. Oxidation half-equation. (2 marks)

_____

c. Overall reaction. (1 mark)

_____

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Sub-Section [1.9.2]: Identify Key Features of Fuel Cells Including Continuous Supply, Electrolyte Movement and Properties of Electrodes

Question 4 (4 marks)

Galvanic cells are often compared to fuel cells due to their characteristics.

a. State one similarity and one difference between them. (2 marks)

_____

_____

_____

b. State three properties of electrodes in fuel cells. (2 marks)

_____

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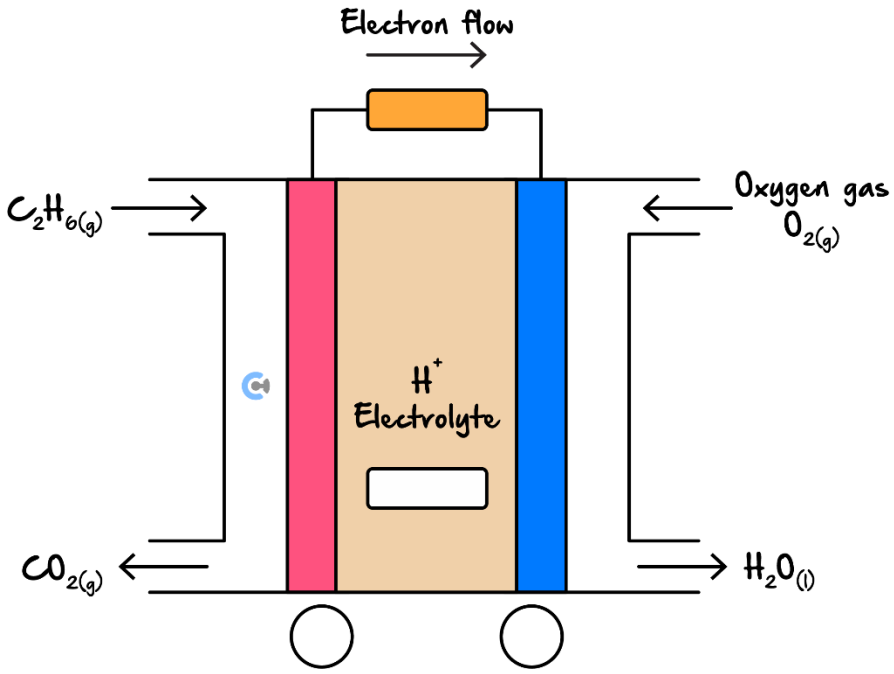
Question 5 (6 marks)

Consider the following fuel cell in acidic conditions.



a. Electrolytes are already present in the fuel cell.

i. Identify the direction of electrolyte movement. (1 mark)

ii. Explain the purpose of the electrolyte. (2 marks)

_____

_____

b. Identify the polarities of the fuel cell. (1 mark)

c. Write the half-equations of the fuel cell.

i. Oxidation. (1 mark)

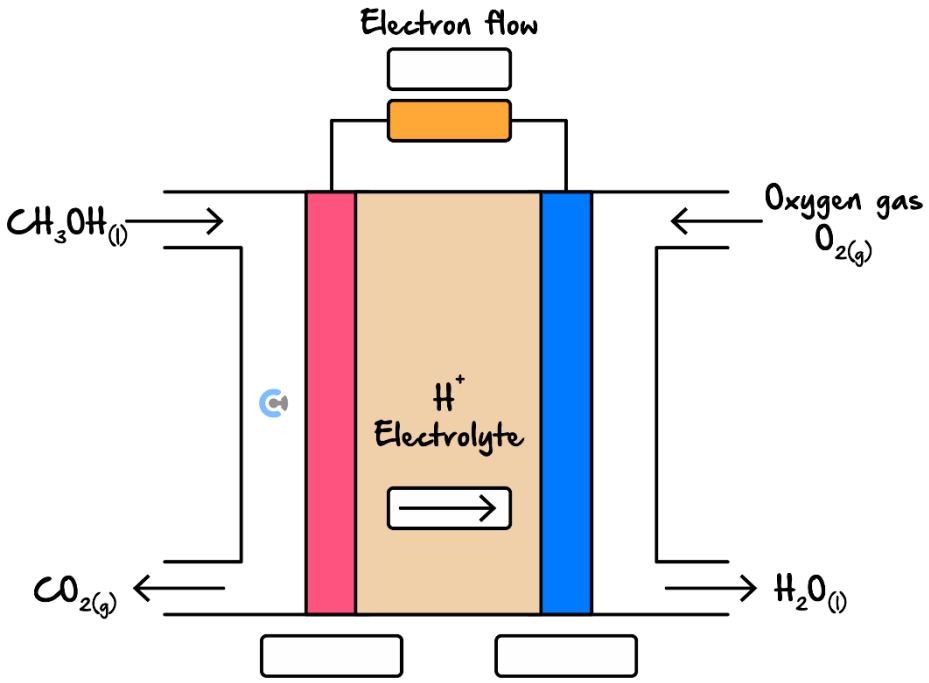
_____

ii. Reduction. (1 mark)

_____

Question 6 (4 marks)

Consider the following fuel cell involving methanol.



a. Write the half-equations of the fuel cell. (2 marks)

_____

_____

b. Label the cathode/anode. (1 mark)

c. Label the electron flow. (1 mark)

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Sub-Section [1.9.3]: Explain Advantages & Disadvantages of Fuel Cells with Reference to Green Chemistry Principles

Question 7 (2 marks)

One of the major advantages of a fuel cell is its energy efficiency. State the green chemistry principle that is related to this aspect and explain how it relates to greenhouse gas emissions, referring to item 26ii of the Data Book.

_____

_____

_____

Question 8 (2 marks)

One advantage of using methane in fuel cells rather than a gas-fired power station is their energy efficiency. State one other advantage of using methane in a fuel cell, referencing green chemistry principles, referring to item 26ii of the Data Book.

_____

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Question 9 (3 marks)

State 2 disadvantages associated with fuel cells.

_____

_____

_____

_____

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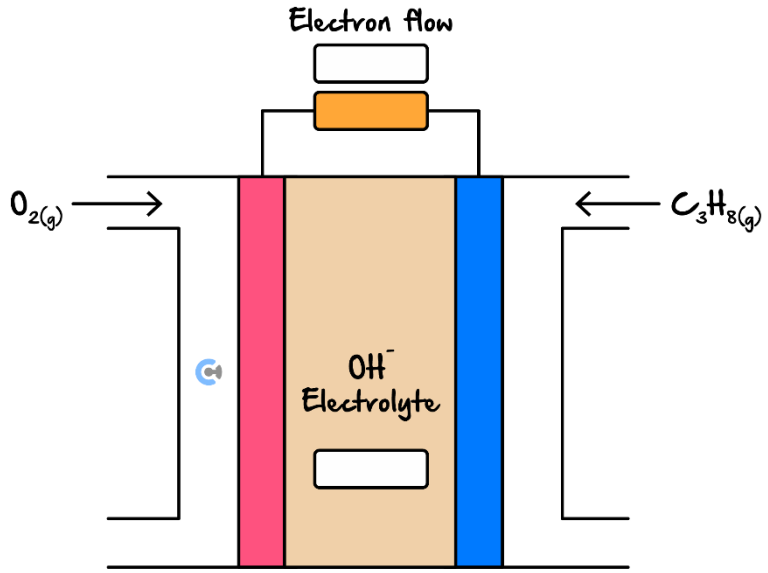
Sub-Section [1.9.4]: Write Fuel Cell Equations in Non-Acidic Conditions

Question 10 (4 marks)

Consider the following fuel cell involving propane and oxygen below.



a. Write the half-equations. (2 marks)

_____

_____

b. Label the direction of electrolyte and electron movement in the respective boxes in the provided space above. (2 marks)

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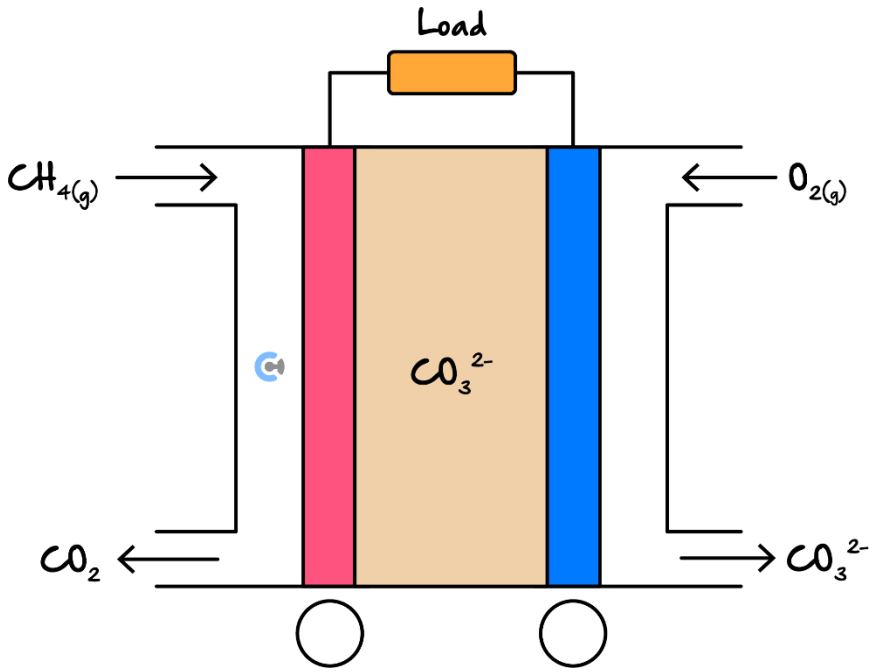
Question 11 (3 marks)

Consider the following fuel cell involving methane and oxygen gas, along with a carbonate electrolyte.



a. Label the polarities of the electrodes. (1 mark)

b. Write the associated half-equations of the fuel cell. (2 marks)

_____

_____

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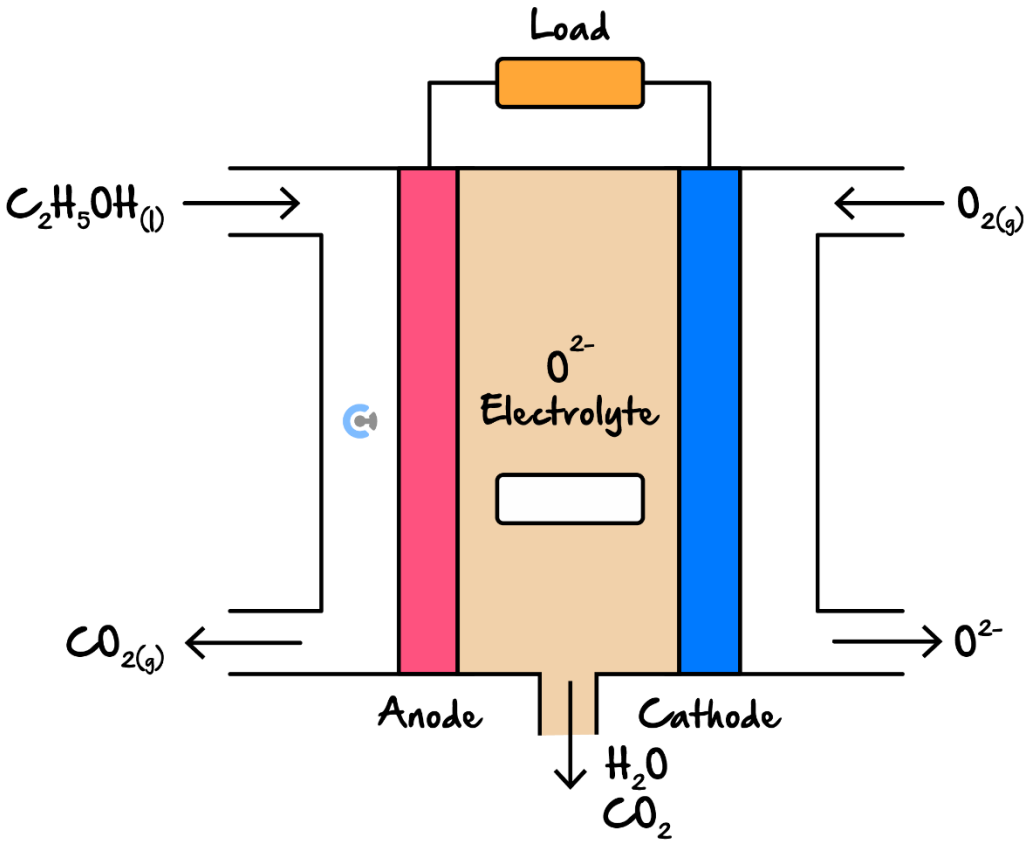
Question 12 (4 marks)

Consider the Solid Oxide Fuel Cell (SOFC) below, which uses ethanol as its primary fuel source.



a. Label the direction of electrolyte movement. (2 marks)

b. Write the half-equations associated with the fuel cell. (2 marks)

_____

_____

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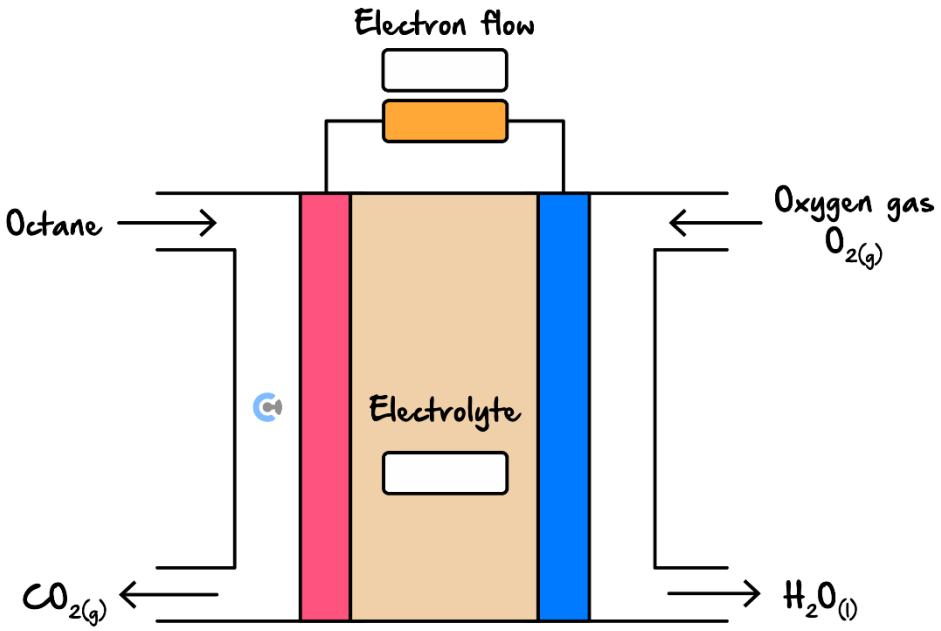
Sub-Section: The 'Final Boss'

Question 13 (9 marks)

Consider a fuel cell that uses octane, in **basic** conditions, as an innovative alternative to traditional combustion engines used in cars.



a. Identify a key characteristic of fuel cells. (1 mark)

_____

b. Write the half-equations occurring at the:

i. Positive electrode. (1 mark)

_____

ii. Negative electrode. (1 mark)

_____

c. Identify the electron and electrolyte movement in the respective boxes provided above. (2 marks)

d. State and explain one advantage and disadvantage of using an octane fuel cell when compared to the usage of ethanol in an internal combustion engine. Justify your answer with reference to green chemistry principles on item 26ii of the Data Book. (4 marks)

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Section B: Supplementary Questions (62 Marks)

Sub-Section [1.9.1]: Write Fuel Cell Half & Overall Reactions in Acidic Conditions

Question 14 (2 marks)

Consider a fuel cell between hydrogen gas, as the fuel, and oxygen gas. Remember to include states in your answer.

a. Hydrogen gas. (1 mark)

_____

b. Oxygen gas. (1 mark)

_____

Question 15 (3 marks)

For each of the following, write the balanced half-equation for the reaction occurring at the anode in acidic conditions. Assume that carbon dioxide is produced.

a. A fuel cell involving ethanol as a reactant. (1 mark)

_____

b. A fuel cell involving ethane as a reactant. (1 mark)

_____

c. A fuel cell involving propanol as a reactant. (1 mark)

_____

Question 16 (4 marks)

Write the half-equations for the fuel cell reaction involving butanol and oxygen gas.

a. Reduction half-equation. (1 mark)

_____

b. Oxidation half-equation. (2 marks)

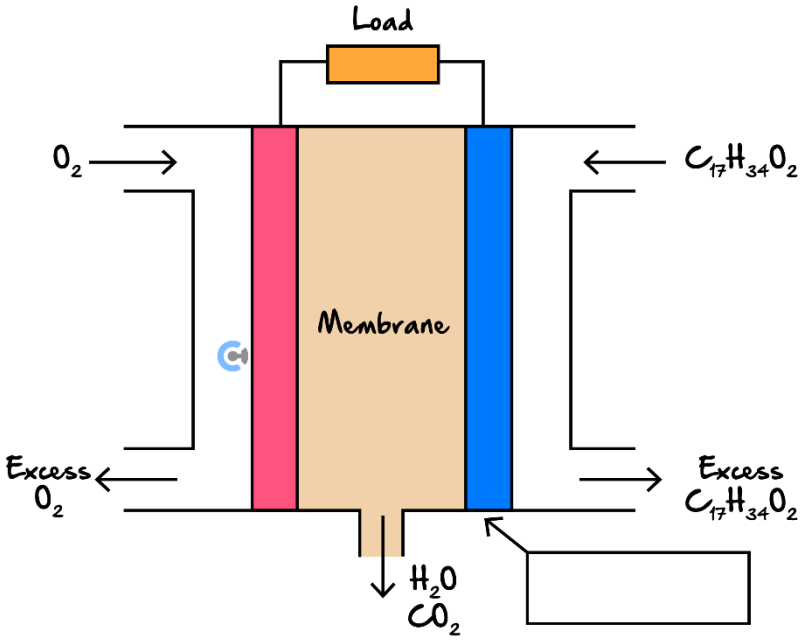
_____

c. Overall reaction. (1 mark)

_____

Question 17 (7 marks)

Biodiesels are an example of a renewable fuel. Some farming equipment manufacturers have tried to make a fuel cell in order to more efficiently use left over livestock feed. A diagram of an acidic biodiesel fuel cell is shown below.



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

b. Write the half-equation for the reaction occurring at the anode. (2 marks)

_____

c. Write a balanced equation for the overall reaction which takes place at SLC. (2 marks)

_____

d. Explain whether this cell would be considered renewable or not. (2 marks)

_____

_____

_____

_____

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Sub-Section [1.9.2]: Identify Key Features of Fuel Cells Including Continuous Supply, Electrolyte Movement and Properties of Electrodes

Question 18 (2 marks)

Explain the key characteristic of a fuel cell.

_____

_____

Question 19 (3 marks)

For the following table, mark each statement as either True or False, with regards to a fuel cell involving methane and oxygen gas in acidic conditions.

Statement	True	False
a. The overall reaction is the same as combustion.		
b. Electrons flow from anode to cathode.		
c. Oxygen reacts at the anode.		
d. Electrodes must always be inert.		
e. The energy conversion is direct.		

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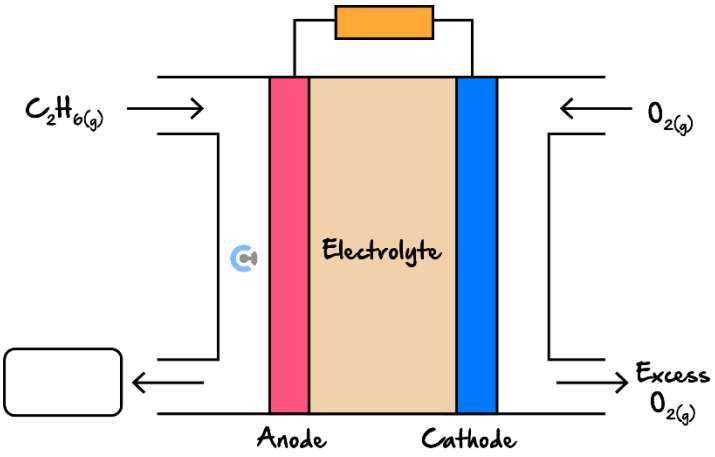
Question 20 (5 marks)

Ethane is a common fuel used in fuel cell.



a. Write the balanced redox reaction for:

i. The half-reaction occurring at the anode. (1 mark)

_____

ii. Label the main product in the blank box provided above. (1 mark)

b. State three different qualities electrodes in fuel cells must possess. (3 marks)

_____

_____

_____

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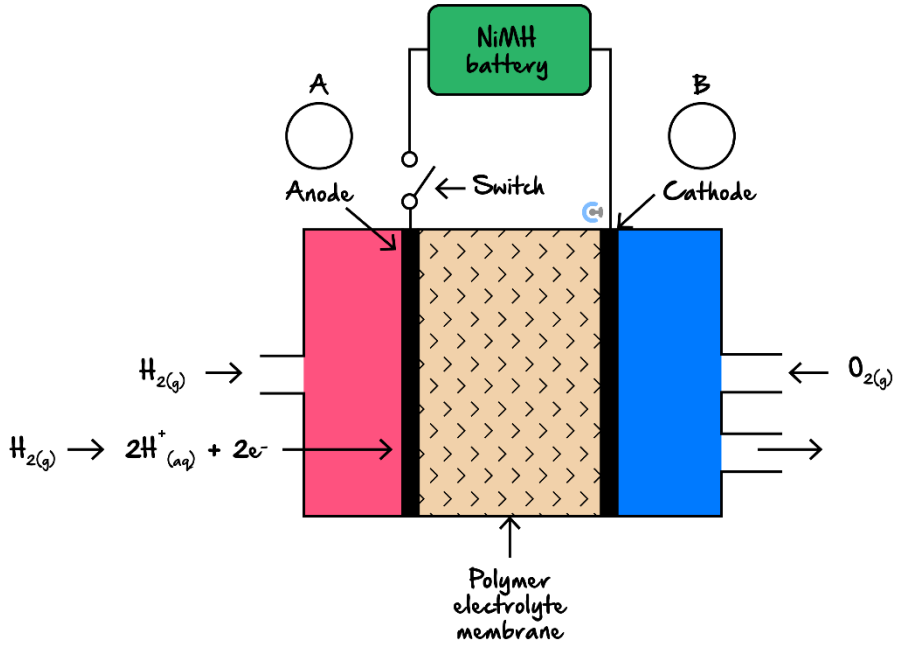
Question 21 (6 marks)

An example of the real-life design of a hydrogen fuel cell is shown below.



a. On the diagram above, indicate the polarity of the anode and cathode in circles *A* and *B*. (1 mark)

b. Write the overall reaction occurring in the cell. (1 mark)

_____

c. Explain the function of the polymer electrolyte membrane in the operation of the cell. (2 marks)

_____

_____

_____

d. State and explain whether this cell is more efficient than a typical combustion engine. (2 marks)

_____

_____

_____

Sub-Section [1.9.3]: Explain Advantages & Disadvantages of Fuel Cells with Reference to Green Chemistry Principles

Question 22 (2 marks)

State and explain one reason why we would use a fuel cell over a galvanic cell.

Question 23 (2 marks)

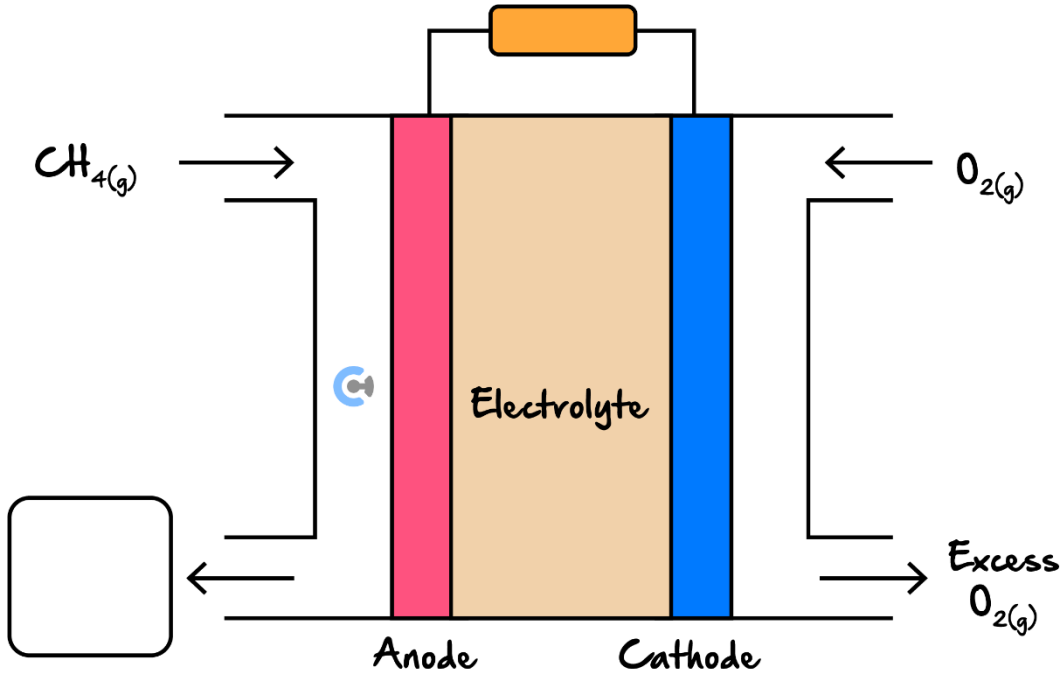
One environmental advantage of using hydrogen fuel cells instead of gas-powered engines is the reduction of greenhouse gas emissions. State one other environmental advantage, referencing green chemistry principles.

Question 24 (3 marks)

State two limitations of hydrogen fuel cells in practical applications.

Question 25 (7 marks)

Methane can be a source of energy in combustion engines. A fuel cell involving methane is shown below.



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

i. Anode. (1 mark)

_____

ii. Cathode. (1 mark)

_____

b. In the diagram above, label the expected product(s) at the anode. (1 mark)

c. Compare the efficiency and viability of a combustion engine as opposed to a fuel cell, referencing green chemistry principles. (2 marks)

_____

_____

_____

d. A scientist is aiming to produce an engine that can produce mass amounts of energy at a single time. Explain whether he should use a fuel cell or an internal combustion engine. (2 marks)

_____

_____

_____

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Sub-Section [1.9.4]: Write Fuel Cell Equations in Non-Acidic Conditions

Question 26 (1 mark)

Write the balanced oxidation half-equation in basic conditions of methane oxidising into carbon dioxide.

_____

Question 27 (3 marks)

For each of the following, write the balanced oxidation half-equation in basic conditions. Assume CO_2 is the only carbon product formed.

a. A fuel cell involving ethane as a reactant. (1 mark)

_____

_____

b. A fuel cell involving propanol as a reactant. (1 mark)

_____

_____

c. A fuel cell involving methanol as a reactant. (1 mark)

_____

_____

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Question 28 (5 marks)

The overall equation for an unknown fuel cell is shown below, in alkaline conditions.

$$X(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$$

a. What is the equation for the reaction that occurs at the cathode? (1 mark)

_____

b. If the fuel itself was an alkane, what could its identity be? (2 marks)

_____

c. Hence, write the half-equation for the reaction that would occur at the anode. (2 marks)

_____

_____

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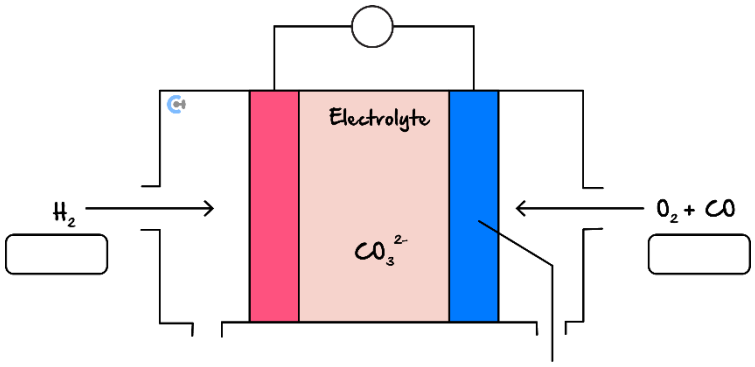
Question 29 (7 marks)

A simplified diagram of a molten carbonate fuel cell (MCFCs) is shown below.



In this MCFC, hydrogen is being used as a reactant alongside $O_2(g)$ in order to produce energy. The main carbon containing product of the cell is carbon monoxide.

a. On the diagram above, label the:

i. Anode and cathode along with the polarities of either electrode. (1 mark)

ii. The direction of electron flow in the external circuit. (1 mark)

b. Write a balanced half-equation for the cathode. (1 mark)

_____

c. Write the balanced half-equation for the anode. (2 marks)

_____

d. Explain one property of the electrodes in this fuel cell. (2 marks)

_____

_____

_____

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