

## Structured Questions

# Energy from Fuels

Combustion Reactions / Incomplete Combustion / The Amount of Carbon Dioxide Produced When Fuels Burn / Carbon Dioxide Levels & the Greenhouse Effect / Biofuels / Fuel Cells

Easy (3 questions)	/22
Medium (3 questions)	/33
Hard (3 questions)	/20
<b>Total Marks</b>	<b>/75</b>

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# Easy Questions

- 1 (a) State the difference between complete and incomplete combustion of a hydrocarbon fuel, such as octane, including the products formed.

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**(2 marks)**

- (b) Write a balanced symbol equation for the complete combustion of decane,  $C_{10}H_{22}$ .

.....  
.....

**(2 marks)**

- (c) Decane is a major component of diesel fuel.

- i) Write a balanced symbol equation for the incomplete combustion of decane,  $C_{10}H_{22}$ , forming carbon as one product. [1]
- ii) What might you observe to tell you that carbon is being formed? [1]

.....  
.....

**(2 marks)**

**2 (a)** Carbon dioxide is one example of a greenhouse gas.

i) Name **two** other greenhouse gases.

[2]

ii) What type of radiation do all greenhouse gases absorb?

[1]

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.....

.....

**(3 marks)**

**(b)** State **three** human activities contribute to increased levels of carbon dioxide in the atmosphere.

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.....

.....

**(3 marks)**

**(c)** One way to reduce climate change is by replacing fossil fuels with biofuels.

Explain why fossil fuels contribute more to climate change than biofuels.

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**(1 mark)**

**3 (a)** Methanol can be formed as a by-product during fermentation to form bioethanol.

Suggest why methanol produced in the bioethanol fermentation process can be considered a biofuel.

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.....  
**(1 mark)**

**(b)** Write an equation for the complete combustion of methanol.

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.....  
**(2 marks)**

**(c)** State **one** advantage and **one** disadvantage of the methanol fuel cell compared to a hydrogen fuel cell.

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.....  
**(2 marks)**

**(d)** At room temperature and pressure, methanol has a density of  $0.792 \text{ g cm}^{-3}$ .

i) Use the following equation to calculate the volume, in  $\text{cm}^3$ , of one mole of methanol at room temperature and pressure.

$$\text{Volume} = \frac{\text{mass}}{\text{density}}$$

[2]

ii) State the volume, in  $\text{cm}^3$ , of one mole of hydrogen gas at room temperature and pressure.

[1]

iii) Use values from parts (i) and (ii) to suggest why storing and transporting methanol is easier than hydrogen.

[1]  
.....  
.....

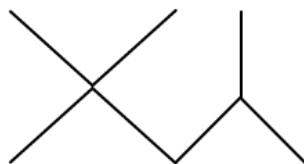
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**(4 marks)**

# Medium Questions

- 1 (a) Isooctane, which is added to petrol to increase the octane rating, burns smoothly in a car engine. It is a branched chain isomer of octane, with the skeletal formula shown below.



- i) Give the IUPAC name for isooctane. [1]
- ii) Suggest, giving a reason, whether octane or isooctane would have the higher boiling point. [3]

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(4 marks)

- (b) In the high temperatures in a car engine with the presence of oxygen, alkanes undergo combustion to release heat energy.

The structures of three alkanes are given.



Alkane A



Alkane B



Alkane C

- i) Define the terms complete and incomplete combustion. [4]
- ii)

Name the alkane, giving a reason, which is most likely to undergo incomplete combustion.

[2]

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**(6 marks)**

**(c)** Write an equation for the complete combustion of isooctane.

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**(1 mark)**

**(d)** The toxic gas carbon monoxide can be produced during incomplete combustion.

Explain why carbon monoxide is dangerous if inhaled.

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**(2 marks)**

**(e)** A diesel fuel containing the hydrocarbon tetradecane,  $C_{14}H_{30}$ , burns with a sooty yellow flame.

Write a balanced symbol equation, including state symbols, for the reaction described.

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**(1 mark)**

- 2 (a)** Fuel cells are used to generate an electric current and do not need to be electrically recharged. The Gemini and Apollo moon probes use hydrogen-oxygen fuel cells. The product of this reaction can be used to supplement the drinking water for astronauts.

Deduce the half equations for the reactions at each electrode in a hydrogen oxygen fuel cell, and then the overall equation for the hydrogen-oxygen fuel cell, to show the product used to supplement drinking water.

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**(3 marks)**

- (b)** A fuel cell is an electrochemical device which converts chemical energy into electrical energy. A continuous supply of fuel is supplied to one electrode and an oxidant to the other.

i) Explain how an electric current is generated in the fuel cell.

[2]

ii) Suggest why a fuel cell does not need to be recharged.

[1]

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**(3 marks)**

- (c)** The electrodes used in hydrogen fuel cells are often made of a porous mixture of carbon-supported platinum or a porous ceramic material coated in platinum.

State why the electrodes must be porous.

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**(1 mark)**



(d) The General Motors Electrovan was built in 1966. It was the first vehicle powered by a hydrogen fuel cell and could travel at up to 70 mph for 30 seconds.

i) Suggest a main advantage of using hydrogen in a fuel cell rather than an internal combustion engine.

[1]

ii) State why using a fuel cell to power a vehicle has an environmental advantage over the internal combustion engine.

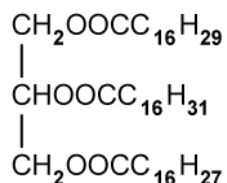
[1]

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**(2 marks)**

3 (a) Vegetable oils are often reacted with methanol in the manufacture of biodiesel.



Write the equation for the reaction of the vegetable oil with methanol.

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.....

**(3 marks)**

(b) State two advantages and two differences associated with the use of biodiesel

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.....

.....

**(4 marks)**

(c) A student carried out a calorimetry experiment to determine the enthalpy of combustion of a sample of biodiesel.

5.0 cm<sup>3</sup> of biodiesel (density = 0.780 g cm<sup>-3</sup>) was introduced into an open flame calorimeter containing 1 dm<sup>3</sup> of water at 20.0 °C. The final temperature of the water was recorded at 55 °C.

i) Calculate the enthalpy change, in kJ, for the experiment. Use section 2 of the Data Booklet.

[2]

ii) Calculate the enthalpy change, in kJ g<sup>-1</sup>, for this sample of biodiesel

[1]

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**(3 marks)**

# Hard Questions

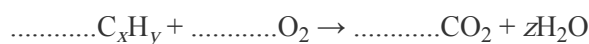
- 1 (a)  $10 \text{ cm}^3$  of a gaseous hydrocarbon,  $\text{C}_x\text{H}_y$ , was reacted with  $100 \text{ cm}^3$  of oxygen gas. The final volume of the gaseous mixture was  $95 \text{ cm}^3$ . This gaseous mixture was treated with concentrated, aqueous sodium hydroxide to absorb the carbon dioxide present. This reduced the gas volume to  $75 \text{ cm}^3$ .

All gas volumes were measured at 298 K and 100 kPa.

Write an equation for the reaction between sodium hydroxide and carbon dioxide.

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.....  
**(1 mark)**

- (b) Use the information in (a) to balance the equation below.



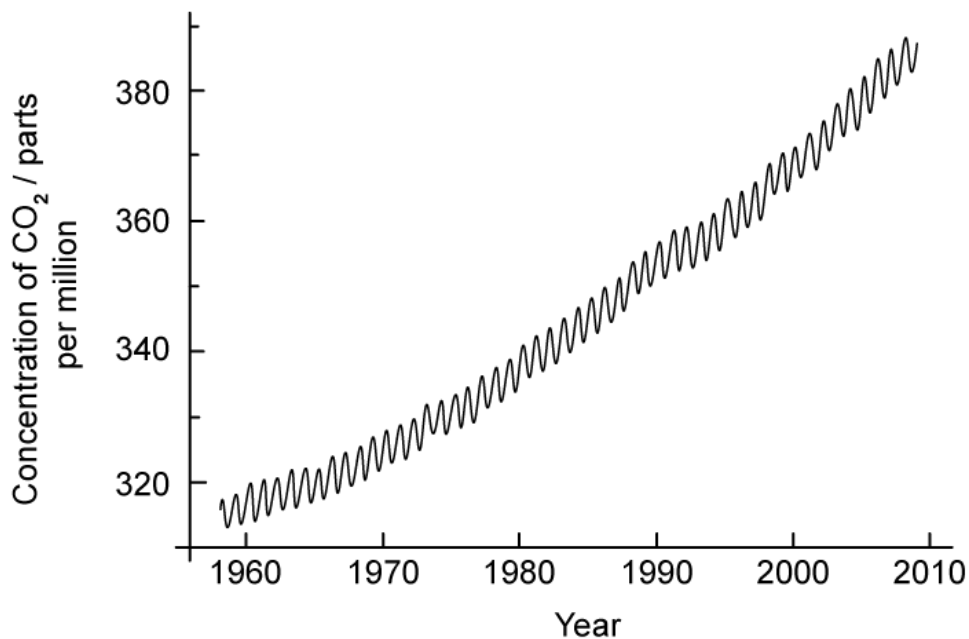
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.....  
.....  
**(3 marks)**

- (c) Deduce the values of  $x$ ,  $y$  and  $z$  in the equation in (b).

.....  
**(1 mark)**

- 2 (a) Climate change, with a focus on carbon dioxide emissions, is a continuing global topic of debate.

The following graph shows the annual increase in the concentration of atmospheric carbon dioxide recorded at Mauna Loa, Hawaii.



Explain why the graph is not smooth.

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(1 mark)

- (b) Explain the molecular mechanism of greenhouse gases, in relation to carbon dioxide.

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(3 marks)

- (c) Gases other than carbon dioxide are known to cause global warming and climate change. Discuss the significance of **two** of these greenhouse gases.

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**(3 marks)**

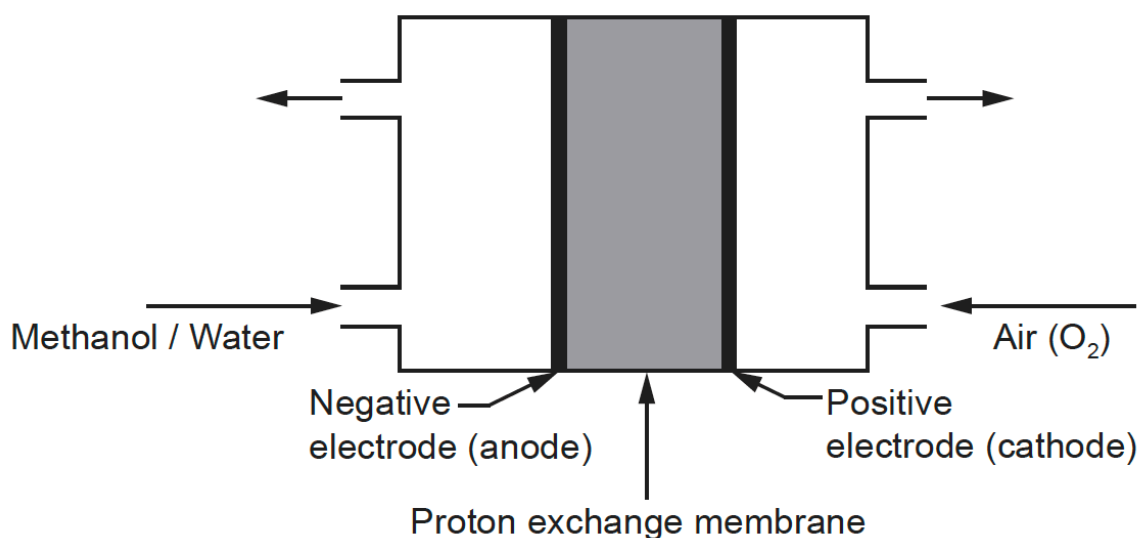
3 (a) Although they are finite, fossil fuels are considered significant sources of energy. Using fossil fuels for electricity production is a very inefficient process with the total possible energy conversion typically around 40%.

Fuel cells are more efficient, often with a 70% conversion.

State the energy change conversion that occurs in fossil fuels and fuel cells.

(1 mark)

(b) One type of fuel cell contains a proton exchange membrane between electrodes and uses aqueous methanol as the fuel.



Deduce the half-equations and the overall equation for the reactions taking place, under acidic conditions, in this fuel cell.

Negative electrode:

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Positive electrode:

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Overall equation:

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(3 marks)

- (c) i) The electrodes of the methanol fuel cell are often made of graphite but they are both covered with a thin layer of platinum.  
State the function of the platinum. [1]
  
- ii) Outline the function of the polymer exchange membrane used in the methanol fuel cell with an acidic electrolyte. [1]
  
- iii) Other than cost, state **two** disadvantages specific to a methanol fuel cell. [2]

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(4 marks)