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VCE Chemistry $\frac{3}{4}$
Fuels [0.4]
Workshop

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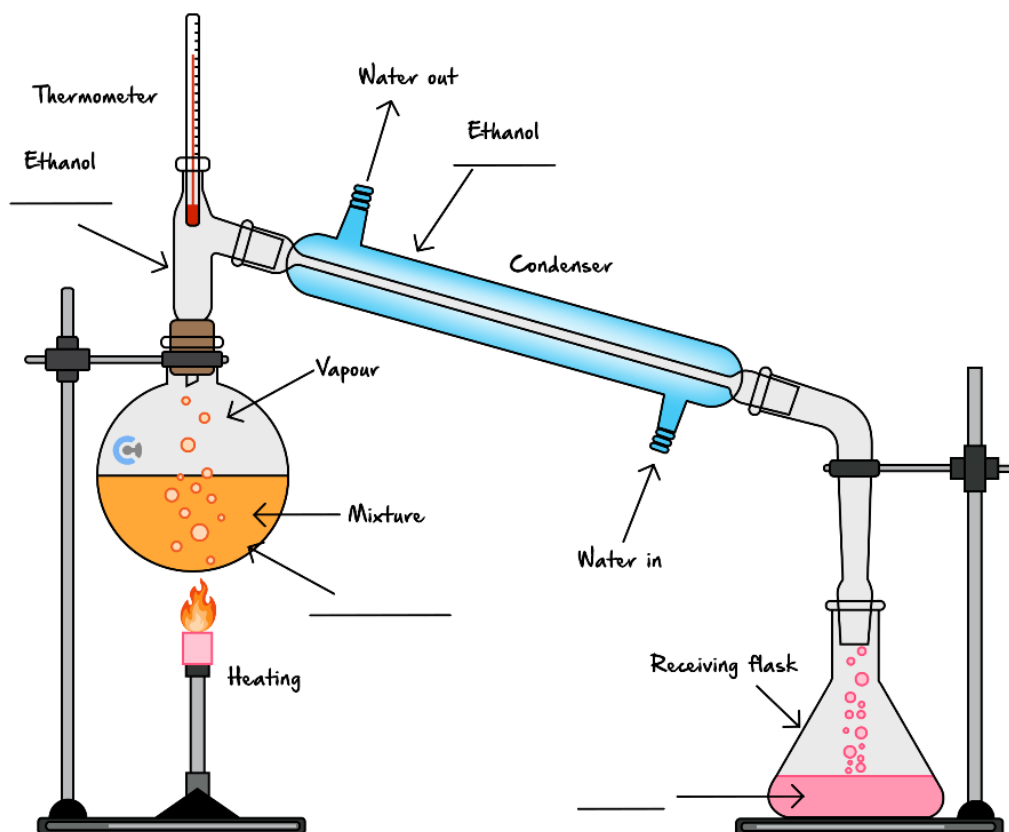
Section A: Recap

Learning Objective: [1.5.1] - Explain The Production Of Biofuels (Biogas, Bioethanol & Biodiesel)



Biofuels	Notes
Biogas	<ul style="list-style-type: none"> Comprised of _____ and carbon dioxide (CO₂). Formation: _____ of organic materials into carbon dioxide (CO₂) and methane (CH₄) by _____.
Bioethanol	<ul style="list-style-type: none"> Formed from the _____ of _____ with the help of _____. $\text{C}_6\text{H}_{12}\text{O}_6(aq) \xrightarrow{\text{yeast}} \underline{\hspace{10em}}$
Biodiesel	<ul style="list-style-type: none"> Biodiesel is a fatty acid methyl ester, and is formed from plant and animal matter via _____!

- **Distillation:** A process of separating a liquid mixture by _____ the mixture.
- **Process:** Mixture is heated to _____.
- **Target Temperature:** Temperature _____ the two substance's boiling points.
- During the distillation of the ethanol and water mixture, [ethanol] / [water] evaporates first.



➤ **Distillate:** The substance which is evaporated and condensed back down in distillation.

➤ **Purpose of Distillation:**

➤ _____ efficiency upon combustion of ethanol as less water is present.

Learning Objective: [1.5.2] - Identify & Explain Differences Between Fossil Fuels & Biofuels With Reference To Renewability, Heat Of Combustion & Carbon Neutrality



➤ Renewable fuel can be replenished by _____ within a _____.

➤ A fuel which already has some oxygens in the molecular formula is considered to be _____.

➤ This results in a [higher] / [lower] heat of combustion.

➤ Biogas, bioethanol and biodiesel are considered to be **carbon neutral** as the CO_2 released upon use is previously absorbed via _____.

➤ However, they are not 100% carbon neutral due to _____ and _____.



Learning Objective: [1.5.3] - Write Cellular Respiration & Photosynthesis Equations

- Cellular Respiration is the process in which humans _____.
- Cellular Respiration Thermochemical Equation:

- Photosynthesis occurs in _____.
- Photosynthesis Equation:



Learning Objective: [1.5.4] - Calculate Energy Obtained From Foods & Compare The Energy Values Between Carbohydrates, Proteins And Fats

- Energy obtained from foods can be calculated by the formula: _____.
- Humans [can] / [cannot] obtain energy from cellulose.
- Fats have the [highest] / [lowest] energy content of all food classes because it is [more] / [less] partially oxidised.

Space for Personal Notes

Section B: Warm Up (14 Marks)

INSTRUCTION: 14 Marks. 9 Minutes Writing.



Question 1 (9 marks)

Biogas, bioethanol and biodiesel are three biofuels which are gaining more use in recent years.

a. Firstly bioethanol is to be investigated.

i. Describe the production of bioethanol, including an equation to show how it is formed. (3 marks)

ii. Why is ethanol sourced from crude oil considered to be a fossil fuel, but ethanol sourced from bioethanol is considered a biofuel? (2 marks)

b. Biogas is then investigated.

- i. How much energy would be produced by completely combusting the contents of a full 50.0 L biogas container at SLC given that 60.0% of the biogas is methane and the rest is carbon dioxide? (2 marks)

- ii. If the composition were 70% methane: 30% CO₂, would the energy released upon combustion be greater than the same, or less than that in **part b. i.**? **No calculations are required.** (1 mark)

c. Describe how biodiesel is created. (1 mark)

Space for Personal Notes

Question 2 (5 marks)

Corn makes up a large proportion of people's diet in some parts of the world. Air-popped popcorn is made from whole corn kernels. The nutrition content of a particular type of air-popped popcorn is provided in the table below.

	Average quantity per 100 g
Protein	10.7 g
Fat	5.0 g
Carbohydrates	78.7 g

- a. Using the information provided in the table above, calculate the energy content of air-popped popcorn in kilojoules per gram. (2 marks)

b.

- i. Write the reaction which shows how energy is obtained from the carbohydrates in the body. (1 mark)

- ii. If 3.50 g of glucose is respired, find the volume of carbon dioxide gas that is formed. (2 marks)

Section C: Ramping Up (13 Marks)

INSTRUCTION: 13 Marks. 10 Minutes Writing.



Question 3 (3 marks)

A student eats bananas every recess and always chucks the peel onto the footy oval. Over the next few days, a chemical reaction occurs which forms some chemicals.

- a. State which chemicals are formed. Justify your reasoning. (2 marks)

- b. The chemicals are captured and then combusted at SLC. Write the balanced chemical equation for the reaction which occurs. (1 mark)

Question 4 (3 marks)

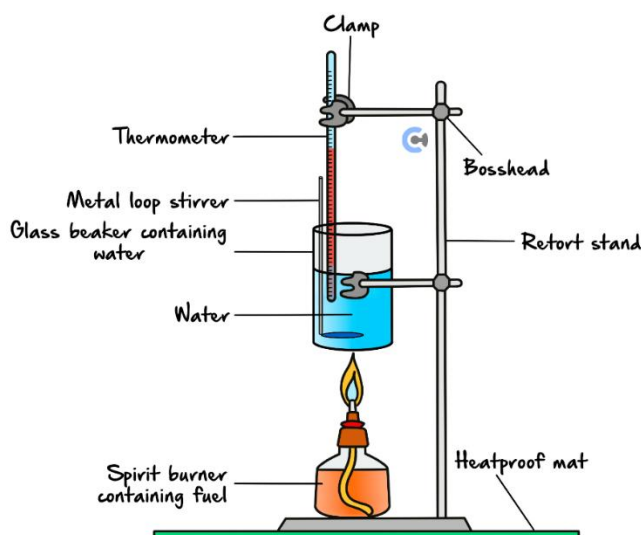
Joel loves eating chocolate, which is obtained from cocoa beans. He knows that the chocolate he eats has 30.0% (*m/m*) glucose and 8.00% (*m/m*) fibre.

- a. Write the equation which shows how this glucose is formed in the cocoa trees. (1 mark)

- b. He finds that the remaining 62.0% of the chocolate is comprised of fats and oils. Find the energy content of the chocolate in kJ/g . (2 marks)

Question 5 (7 marks)

Anthony is unsure of the fuel his parents fill his car up with and decides to test out the fuel's capabilities to identify the fuel. He obtains a sample of the fuel and puts it in the spirit burner (with a total mass of 223.10 g) with the rest of the apparatus as shown below.



He burns the fuel, heating the 301.5 mL of water from 17.0°C to 64.0°C, leaving a spirit burner with a mass of 221.10 g.

- a. Calculate the heat of combustion of the fuel, in kJ/g^{-1} and hence or otherwise, state the likely classification of the fuel. (3 marks)

- b. Discuss the advantages regarding the environmental impact of ethanol compared to the environmental impact of octane. (4 marks)

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Section D: Ramping Up (11 Marks)

INSTRUCTION: 11 Marks. 9 Minutes Writing.



Question 6 (11 marks)

Two former VCE Chemistry students decided to team up and start a business of home-brewing various 'light' alcoholic beverages. Their vision is to create drinks that can be consumed on a night out while still keeping their Blood Alcohol Concentration (BAC) under the legal limit.

In an attempt to be creative, they buy dozens of pears and place them into a barrel for 2 years.

- a.** Would this process outlined above have generated the desired ethanol? Explain why or why not. (1 mark)

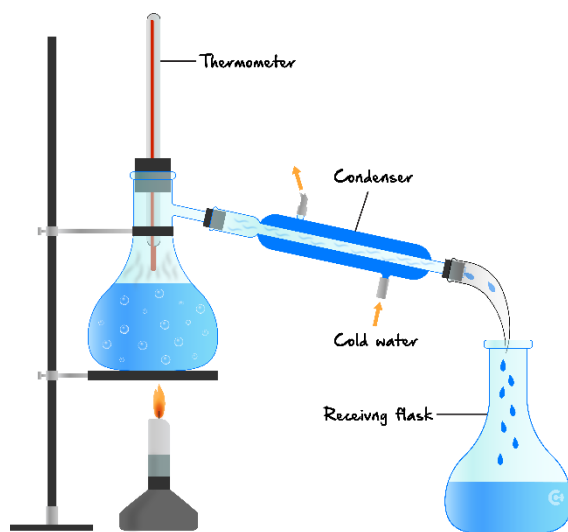
- b.** Outline how the above process of producing bioethanol upholds the definition of renewability, assuming any relevant changes suggested in **part a.** have been implemented. (1 mark)

c.

- i. If 20.0 kg of pears were placed inside the 50 L barrel, and pears are comprised of 75.0% glucose by mass, calculate the amount, in *mol*, of bioethanol that could theoretically be produced. (2 marks)

- ii. If this ethanol was then transported to a factory where it was added to 2 tonnes of water to produce a beverage, find the % w/w of bioethanol in the drink. (1 *tonne* = 1000 kg). (2 marks)

- d. One of the VCE students decides to distil the bioethanol to increase the proportion of ethanol present. He uses the following setup to undergo simple distillation.



- i. Identify the distillate formed. (1 mark)
- _____
- _____
- ii. Explain the whole process in which the water and ethanol are separated through simple distillation. Refer to the diagram above and specific temperatures in your response. (2 marks)
- _____
- _____
- _____
- _____
- e. Ethanol produced in this manner is considered to be 'carbon offsetting'. Explain the reasoning for this statement, and use an equation to justify your answer. (2 marks)
- _____
- _____
- _____
- _____

Section E: Getting Trickier II (11 Marks)

INSTRUCTION: 11 Marks. 10 Minutes Writing.



Question 7 (7 marks)

A student set up a solution calorimeter to determine the heat of combustion of proteins. To do so, they made use of a homemade protein bar which is almost purely protein and contains a small proportion of carbohydrates.

- a. To begin with, they calibrated the calorimeter by passing a current of 5.0 A and a potential difference of 28.0 V for 20.0 minutes and observed an increase of 2.3 K in the temperature of the calorimeter.

- i. Calculate the calibration factor of the calorimeter in $\text{kJ } ^\circ\text{C}^{-1}$. (2 marks)

- ii. They then dissolved their protein bar, which was 50 g initially and 37.8 g at the end, in the solution calorimeter and noticed that the water's temperature went from 20.0°C to 29.1 K .

Find the energy content of protein according to the student's observations. (3 marks)

b. The small proportion of carbohydrates present in the protein bar is made up of cellulose from beans.

i. Write the equation which shows the process in which the glucose in the cellulose is formed. (1 mark)

ii. It can be assumed in calculations in **part a.** that the cellulose present from these beans has a negligible effect on the energy content obtained. Explain why this assumption could be made. (1 mark)

Question 8 (4 marks)

A sample crude oil can be separated into multiple constituents such as petrol, kerosene and diesel.

a. Identify the process which separates crude oil into its constituents. (1 mark)

b. A 10.0 L sample of crude oil was separated into 32.0 % $\left(\frac{v}{v}\right)$ of kerosene, 12.3 % $\left(\frac{v}{v}\right)$ of petrol and the remainder of other substances. The kerosene and petrol are then completely combusted.

Find the total amount of energy released upon the combustion of the kerosene and petrol obtained in megajoules. (3 marks)

*Let's take a **BREAK!***



Section F: VCAA-Level Questions I (11 Marks)

INSTRUCTION: 11 Marks. 30 Seconds Reading. 10 Minutes Writing.



Question 9 (3 marks)



Inspired from VCAA Chemistry Exam 2022

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2022/2022chem-w.pdf#page=16>

A coal-fired power station is used to generate electricity. Carbon dioxide, CO_2 , gas is produced as part of the process.

- a. Carbon capture and storage is one option being considered to reduce the amount of CO_2 released into the atmosphere. $5.17 \times 10^4 \text{ mol}$ of CO_2 is captured, cooled to 25.0°C and stored in a sealed tank at standard pressure prior to transportation.

Calculate the capacity of the tank, in megalitres, when it contains $5.17 \times 10^4 \text{ mol}$ of CO_2 . (1 mark)

- b. This CO_2 was collected from a gas-fired power station, which has a 60% energy efficiency, combusting pure propane in the same conditions as the tank. Calculate the amount, in moles, of propane burned. Justify each step of your working. (2 marks)

Space for Personal Notes


Question 10 (8 marks)

Inspired from VCAA Chemistry Exam 2020
<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2020/2020chem-w.pdf#page=26>

Methane gas, CH_4 , can be captured from the breakdown of waste in landfills. CH_4 is also a primary component of natural gas. CH_4 can be used to produce energy through combustion.

- a. Write the equation for the incomplete combustion of CH_4 to produce soot, C. (1 mark)

- b. If 20.0 g of CH_4 is kept at 25°C and 100 kPa in a container, what would be the capacity of the container? (2 marks)

- c. A bunsen burner is used to heat a beaker containing 350.0 g of water. Complete combustion of 0.485 g of CH_4 raises the temperature of the water from 20°C to 32.3°C.

Calculate the percentage of the Bunsen burner's energy that is transferred to the water. (3 marks)

- d. Compare the environmental impact of CH_4 obtained from landfills to the environmental impact of CH_4 obtained from natural gas. (2 marks)

Space for Personal Notes

Section G: Multiple Choice Questions (8 Marks)

INSTRUCTION: 8 Marks. 8 Minutes Writing.



Question 11 (1 mark)

The human body cannot obtain any energy from the polysaccharide cellulose. This is because:

- A. Cellulose is not present in any of the foods we eat.
- B. The molecules produced from the digestion of cellulose cannot be absorbed by the gut.
- C. The molecules produced from the digestion of cellulose are unable to be oxidised in human body cells.
- D. The human body lacks the enzymes required to digest cellulose.

Question 12 (1 mark)



Inspired from VCAA Chemistry Exam 2020

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2020/2020chem-w.pdf#page=7>

Which one of the following statements is not correct?

- A. Crude oil cannot be classified as a biofuel even though it originally comes from plants.
- B. Methane CH_4 , can be classified as a fossil fuel as it is derived from decomposed organisms trapped under layers of sediment.
- C. Ethanol, $\text{CH}_3\text{CH}_2\text{OH}$, can be classified as a fossil fuel because it can be produced from crude oil.
- D. Hydrogen, H_2 , can be classified as a biofuel because, when it combusts, it does not produce carbon dioxide, CO_2 .

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Question 13 (1 mark)

Which one of the following is likely to be a biofuel?

- A. A gas mixture containing 95% methane and 5% carbon dioxide.
- B. Ethanol obtained via fractional distillation.
- C. Petrodiesel, with a large non-polar hydrocarbon chain.
- D. A gas mixture containing 60% methane and 40% carbon dioxide.

Question 14 (1 mark)

Which element(s) are expected to be more abundant in mixtures of biofuels compared to mixtures of fuels sourced from crude oils?

- A. Oxygen
- B. Carbon and Hydrogen
- C. Nitrogen and Sulphur
- D. Chlorine and Bromine

Question 15 (1 mark)

The complete combustion of which of the following produces the greatest amount of energy?

- A. 0.028 *kL* of methane at SLC.
- B. 1.3×10^2 *mmol* of biodiesel which has a heat of combustion of 45 *kJ/g* and a molar mass of 292 *g/mol*.
- C. 38 *g* of methanol.
- D. 12 *L* of LPG, which consists of 4 *L* of propane and 8 *L* of butane at SLC.

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Question 16 (1 mark)

100 mL of a gaseous hydrocarbon is mixed with 500 mL of oxygen at 25°C and 100 kPa pressure and sparked. At the end of the reaction, the gaseous mixture is returned to its original temperature and pressure. The final mixture consists of 300 mL of carbon dioxide and 50 mL of oxygen. The molecular formula of the hydrocarbon is:

- A. C₂H₄
- B. C₃H₄
- C. C₃H₆
- D. C₂H₆

Question 17 (1 mark)


Inspired from VCAA Chemistry Exam 2018

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2018/2018chem-w.pdf#page=9>

Four fuels undergo complete combustion in excess oxygen, O₂, and the energy released is used to heat 500 mL of water.

Assuming there is no energy lost to the environment, which one of these fuels will increase the temperature of the water from 25.0°C to 85.0°C?

- A. 0.889 g of hydrogen, H₂
- B. 3.95 g of propane, C₃H₈
- C. 0.282 mol of methane, CH₄
- D. 0.301 mol of methanol, CH₃OH

Space for Personal Notes

Question 18 (1 mark)

The heat of combustion for three methyl esters is given in the table below.

Name	Formula	ΔH_c (kJ mol^{-1})
Methyl pentanoate	$\text{C}_4\text{H}_9\text{COOCH}_3$	3558
Methyl hexanoate	$\text{C}_5\text{H}_{11}\text{COOCH}_3$	4211
Methyl heptanoate	$\text{C}_6\text{H}_{13}\text{COOCH}_3$	4863

One of the molecules found in biodiesel is methyl stearate, $\text{C}_{17}\text{H}_{35}\text{COOCH}_3$. Based on the table, the best estimate for the heat of combustion (in kJ mol^{-1}) of methyl stearate would be:

- A. 5515
- B. 6226
- C. 12040
- D. 14412

Space for Personal Notes

Section H: VCAA-Level Questions II (14 Marks)

INSTRUCTION: 14 Marks. 30 Seconds Reading. 13 Minutes Writing.



Question 19 (4 marks)

Inspired from VCAA Chemistry Exam 2019

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2019/2019chem-w.pdf#page=40>

Climate change has been identified as a threat to the environment. Fossil fuels are recognised as a significant contributor to the rise in carbon dioxide levels in the atmosphere. The replacement of fossil fuels as an energy source represents a challenge and has been the focus of research for a number of years. However, there are different opinions/views about the suitability of using a biofuel, such as biodiesel, as a replacement for fossil fuels. Some extracts representing different viewpoints are shown in the box below.

1. 'Biofuels are fuels that are produced from biological sources such as trees, plants or microorganisms. They are carbon neutral because they do not result in fossil carbon being released into the atmosphere.'
2. 'All good solutions are needed in the energy transition required to achieve Europe's climate goals – and sustainable biofuels are critical to transport decarbonisation.'
3. 'Many scientists view biofuels as inherently carbon-neutral: they assume the carbon dioxide (CO₂) plants absorb from the air as they grow completely offsets, or "neutralises," the CO₂ emitted when fuels made from plants burn.'
4. '... our analysis affirms that, as a cure for climate change, biofuels are "worse than the disease."'
5. '... although some forms of bioenergy can play a helpful role, dedicating land specifically for generating bioenergy is unwise.'

Sources: 1CarbonNeutralEarth; 2Sejersgård Fanø, quoted in Erin Voegelé, 'EU reaches deal on REDII, sets new goals for renewables', Biodiesel Magazine, 15 June 2018, ; 3 & 4John DeCicco, 'Biofuels turn out to be a climate mistake – here's why', The Conversation, 5 October 2016, ; 5Andrew Steer and Craig Hanson, 'Biofuels are not a green alternative to fossil fuels', The Guardian, 30 January 2015,

Using the chemistry that you studied this year and the information above, discuss the carbon neutrality and the sustainability of using biodiesel as a fuel for transport.

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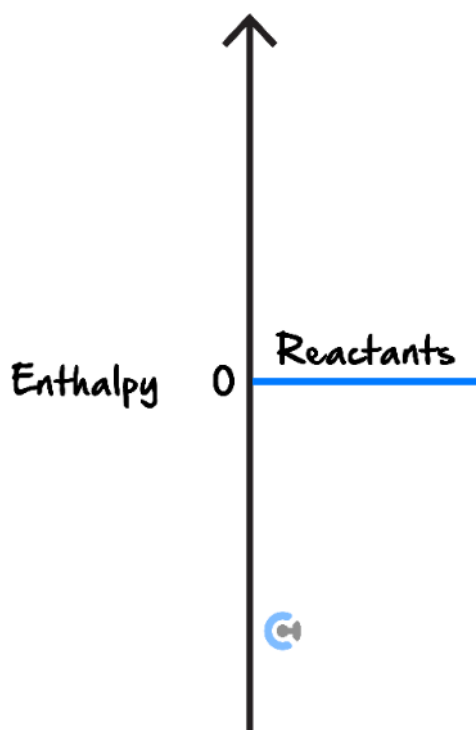

Question 20 (10 marks)

Inspired from VCAA Chemistry NHT Exam 2017

<https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2017/nht/2017chem-nht-w.pdf#page=31>

- a. Write the balanced thermochemical equation for the complete combustion of methane. (2 marks)

- b. Complete and label the incomplete diagram provided below to show the energy profile for the combustion of methane. Label the ΔH , activation energy E_A and the products. (3 marks)



- c. A sample of biogas contains 78.0%, by mass, of methane. This biogas is burnt as a source of energy.

Calculate the maximum amount of energy, in kilojoules, that could be produced from the combustion of the methane present in 100 kg of this biogas. (3 marks)

- d. Identify one advantage and one disadvantage of using biogas as an energy source. (2 marks)

Advantage: _____

Disadvantage: _____

Space for Personal Notes

Section I: Extension Questions (3 Marks)

The following information applies to the two questions that follow.

Last summer, the Victorian government authorised the hire of 105 portable diesel generators for the La Trobe Valley. The generators were brought in as a backup system in case summer electricity demand exceeded supply. The closure of the Hazelwood coal-fired power station led to concerns about Victoria's ability to generate sufficient energy on very hot days.

Question 21 (1 mark)

The main reason behind the selection of diesel generators for this use was that diesel generators:

- A. Produce low levels of emissions.
- B. Use fuel that is renewable.
- C. Are the most efficient way of producing electrical energy.
- D. Produce electrical energy very quickly after start-up.

Question 22 (1 mark)

A typical component of diesel is dodecane. Each molecule of dodecane contains 38 atoms.

The molecular formula of dodecane is:

- A. $C_{12}H_{26}$
- B. $C_{13}H_{26}$
- C. $C_{18}H_{38}$
- D. $C_{38}H_{78}$

Question 23 (1 mark)

Which one of the following lists contains only non-renewable energy sources?

- A. Coal seam gas, petrodiesel, methane gas generated in a digester.
- B. Petroleum gas, coal, methane gas in sea-floor sediments.
- C. Fossil fuels, biofuels, oil trapped in rock formations.
- D. Biogas, bioethanol, diesel composed of methyl esters.

VCE Chemistry $\frac{3}{4}$

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