Website: contoureducation.com.au | **Phone:** 1800 888 300
Email: hello@contoureducation.com.au

VCE Chemistry ¾
Fuels [0.4]
Workshop Solutions

Error Logbook:

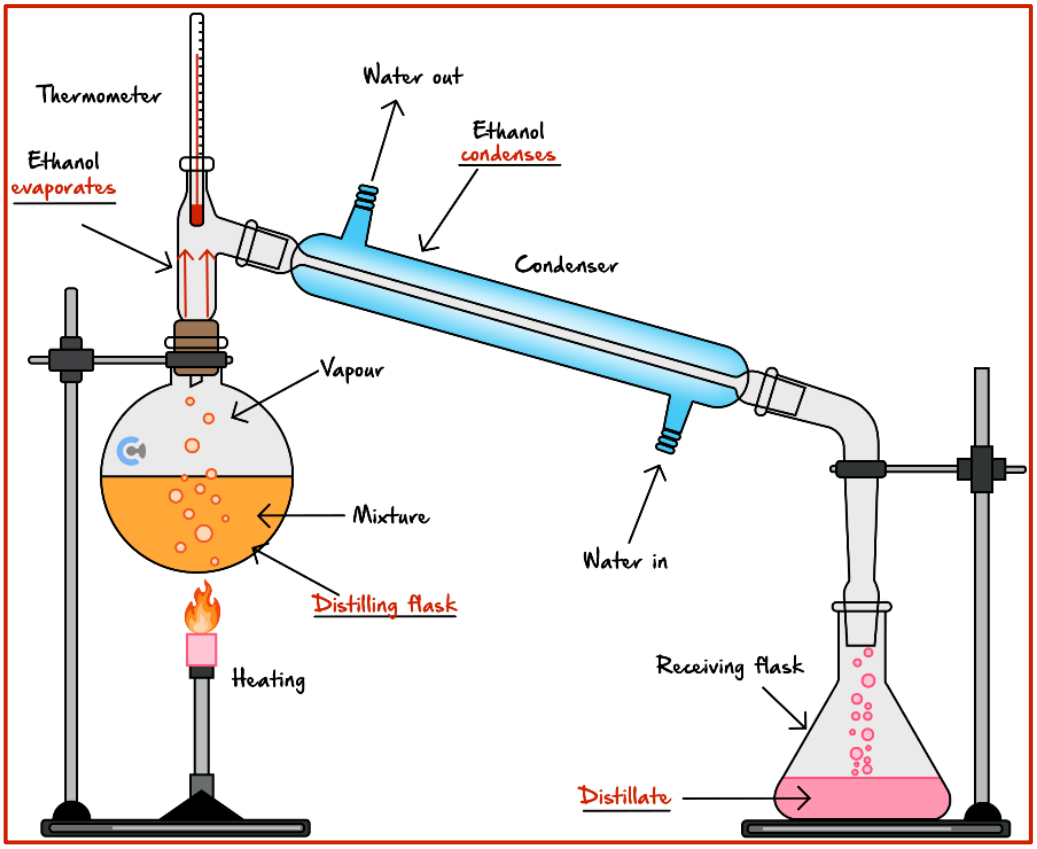
Mistake/Misconception #1		Mistake/Misconception #2	
Question #:	Page #:	Question #:	Page #:
Notes:		Notes:	
Mistake/Misconception #3		**Mistake/Misconception #4**	
Question #:	Page #:	Question #:	Page #:
Notes:		Notes:	

Section A: Recap

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

Biofuels	Notes
Biogas	➢ Comprised of methane (CH_4) and **carbon dioxide (CO_2).** ➢ **Formation**: anaerobic breakdown of organic materials into **carbon dioxide** (CO_2) and **methane** (CH_4) by bacteria.
Bioethanol	➢ Formed from the fermentation **of** sugars (glucose) with the help of yeast. $C_6H_{12}O_6(aq) \xrightarrow{\text{yeast}} 2C_2H_5OH(aq) + 2CO_2(g)$
Biodiesel	➢ Biodiesel is a **fatty acid methyl ester**, and is formed from plant and animal matter via transesterification!

- **Distillation**: A process of separating a liquid mixture by boiling the mixture.
- **Process**: Mixture is heated to target temperature.
- **Target Temperature**: Temperature between 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**:
  - ___Increases___ 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 ___natural processes___ within a ___relatively short time___.
- A fuel which already has some oxygens in the molecular formula is considered to be ___partially oxidised___.
- 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 ___photosynthesis___.
- However, they are not 100% carbon neutral due to ___farming___ and ___transportation___.

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

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

$$C_6H_{12}O_{16}(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l) \ \Delta H = -2840\ kJ/mol$$

- Photosynthesis occurs in ____ plants ____.
- Photosynthesis Equation:

$$6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_{16}(aq) + 6O_2(g) \ \Delta H = -2840\ kJ/mol$$

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: _____ $\Delta H = \frac{q}{m}$ _____.
- 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)

Bioethanol is formed via the fermentation of glucose in the presence of yeast. It is then separated via distillation to remove water.

$$C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$$

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)

Crude oil is non-renewable as it takes millions of years to form, and thus is considered a fossil fuel.

Bioethanol can be produced by natural processes within a relatively short time, and thus is considered a biofuel.

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)

$\mathrm{V}(CH_4) = 0.6 \times 50 = 30\ L$
$\mathrm{n}(CH_4) = V/Vm = 30/24.8 = 1.21\ mol\ *$
$\mathrm{E}(CH_4) = \Delta\mathrm{H} \times n = 1.21 \times 890 \times 1076.6\ kJ\ *$

ii. If the composition were 70% methane: 30% CO_2, 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)

Greater

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

Transesterification reaction from animal/plant fat/oil.

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)

Energy = 10.7 x 17 + 5.0 x 37 + 78.7 x 16

= 181.9 + 185.0 + 1259.2

= 1.63 x10^3 kJ

The second mark was awarded for the correct calculation of energy per gram.

Energy per gram = 1.63 x 10^3 / 100

= 16.3 (kJ g^{-1})

b.

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

$C_6H_{12}O_{6(aq)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(l)}$

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

$n(\text{glucose}) = \frac{m}{M_r} = \frac{3.5}{180} = 0.0194\text{ mol}$

$n(CO_2) = 6n(\text{glucose}) = 0.1167\text{ mol}$

$V(CO_2) = nV_m = 2.89\text{ L}$

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)

Anaerobic breakdown of peels via bacteria would generate biogas CH_4 and CO_2.

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

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$$

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)

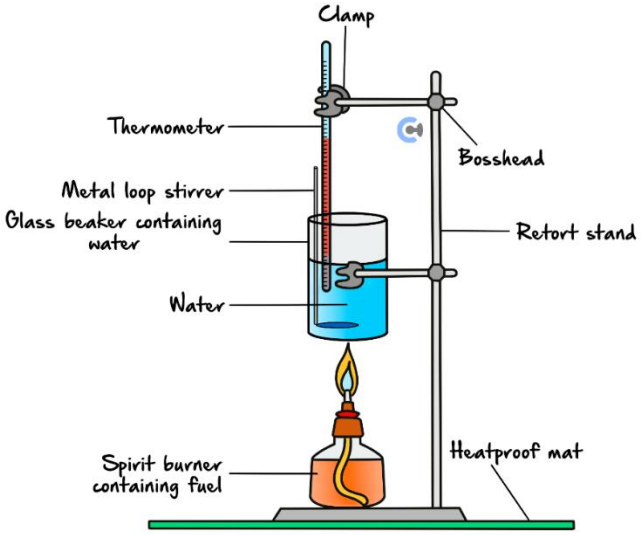
$$6CO_2 + 6H_2O \xrightarrow[\text{Sunlight}]{\text{Chlorophyll}} C_6H_{12}O_6 + 6O_2$$

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)

energy content = 0.3×16 + 0.62×37
= 27.7 kJ/g

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℃ to 64.0℃, 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)

$$m(methanol) = 223.1 - 221.1 = 2.00\ g$$

$$q(water) = mc\Delta T = 301.5 \times 4.18 \times (66 - 17)$$
$$q(water) = 59232.7\ J = 59.2\ kJ$$

$$\Delta H(ethanol) = \frac{q}{m} = 59.2\ kJ\ /\ 2.00\ g = 29.6\ kJ/g \text{ (best)}$$

This matches theoretical ΔH for bioethanol

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

Ethanol can be sourced from bioethanol, which is a renewable fuel as it can be replenished in a relatively short time by natural processes and is **advantageous over octane** as it is non-renewable and formed over millions of years and cannot be replaced by natural processes within a lifetime.

Moreover, ethanol sourced from bioethanol is considered to be carbon neutral as the CO_2 released upon combustion is offset by the CO_2 absorbed during production of glucose via photosynthesis, thereby resulting in less overall CO_2 emissions, **as opposed to octane** which there is no offset whatsoever **and** octane which is sourced from crude oil, can lead to oil spills which can cause harm to marine life.

Space for Personal Notes

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)

Yes, as pears contain glucose and yeast naturally on their skin will ananaerobically ferment the sugars into ethanol.

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)

Short period of time ⟶ 2 years;
natural processes ⟶ yeast ferments the glucose on its own.

c.

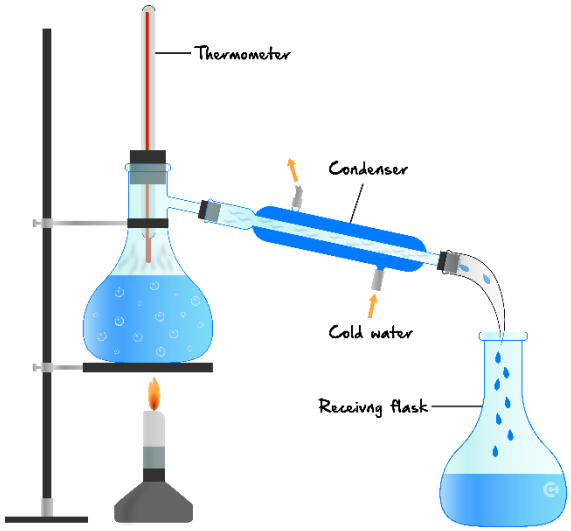
i. If 20.0 kg of pears were placed inside the 50 L barrel, and pears are comprised of 75.0% glucose by mass, calculate the amount, in mol, of bioethanol that could theoretically be produced. (2 marks)

$$n(\text{glucose}) = 0.75 \times 20 \times 10^3/180 = 83.3\ mol$$
$$n(\text{ethanol}) = 2 \times n(\text{glucose}) = 2 \times 83.3 = 167\ mol$$

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)

$$m(\text{ethanol}) = n \times M = 167 \times 46.0 = 7667\ g = 7.667\ kg$$
$$\%\ w/w = 7.667\ kg/2000\ kg \times 100 = 0.383\%$$

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)

Ethanol / Bioethanol

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)

The mixture is heated in the distillation flask to the target tempreature (somewhere between 78°C-100°C), whereby only the ethanol will evaporate. From there, it is passed through the condenser which condenses the ethanol back down into liquid, where it is isolated in the receiving flask.

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)

The CO_2 released upon combustion was previously offset by the CO_2 absorbed during photosynthesis, as shown in the following:

$$6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g) \left(\frac{\text{sunlight}}{\text{chlorophyll}} \text{ on top of arrow}\right)$$

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 $kJ\ °C^{-1}$. (2 marks)

$$E = VIt = 5.0 \times 28.0 \times 1200 = 168\ kJ$$
$$CF = \frac{E}{\Delta T} = \frac{168}{2.3} = 73.0\ kJ\ °C^{-1}$$

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 291 K.

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

$$291\ K = 18°C \longrightarrow \Delta T = 2°C;\ \Delta m = 50 - 37.8 = 12.2\ g\ (1)$$
$$E = CF \times \Delta T = 73 \frac{kJ}{0}°C \times 2°C = 146.1\ kJ\ (2)$$
$$EC = E/\Delta m = 146.1/12.2 = 12.0\ kJ/g\ (3)$$

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)

$6CO_2(g) + 6H_2O(l) \longrightarrow C_6H_{12}O_6(aq) + 6O_2(g)$ ($\frac{\text{sunlight}}{\text{chlorophyll}}$ on top of arrow)

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)

Energy cannot be obtained from cellulose as humans lack the enzyme cellulase to digest it

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)

Fractional distillation

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)

$$q(\text{kerosene}) = \Delta H \times V = 3200\ mL \times 37\frac{kJ}{mL} = 118400\ kJ$$

$$q(\text{petrol}) = \Delta H \times V = 1230\ mL \times 34\frac{kJ}{mL} = 41820\ kJ$$

$$q(\text{total}) = 118400 + 41820 = 160220\ kJ = 1.6 \times 10^2\ MJ$$

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. $5.17 \times 10^4\ mol$ 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 $5.17 \times 10^4\ mol$ of CO_2 . (1 mark)

$$V = n \times V_m = 5.17 \times 10^4 \times 24.8 = 1.28\ ML$$

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)

$n(C_3H_8) = \frac{1}{3} n(CO_2) = \frac{1}{3} \times 5.17 \times 10^4 = 17233.3$ mol

Energy eff doesn't matter - the amount of CO_2 produced is still produced from this amount of C_3H_8

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)

$$CH_4(g) + O_2(g) \rightarrow C(s) + 2H_2O(g)$$

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)

$$n(CH_4) = 20.0 \,/\, 16.0 = 1.25\ mol *$$
$$V(CH_4) = n \times Vm = 1.25 \times 24.8 = 31\ L$$

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)

$$\text{Energy from } CH_4 = 0.485\ \text{g} \times 55.6\ kJ\ g^{-1} = 27.0\ kJ$$
$$\text{Energy absorbed by water} = 4.18\ J\ g^{-1}\ K^{-1} \times 350.0 \times (32.3 - 20.0)$$
$$= 1.80 \times 104\ J = 18.0\ kJ$$

$$\%\ \text{energy transfered} = (18.0 \,/\, 27.0) \times 100 = 66.7\%$$

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

Marks	0	1	2	Average
%	37	44	19	0.8

Similarity – methane from both sources

- Both produce atmospheric carbon dioxide through combustion.
- Methane from both sources contains small amounts of nitrogen and sulfur; combustion of natural gas leads to the formation of acidic oxides such as SO_x and NO_x.

Difference – landfill versus natural gas

- Methane from landfill can be produced renewably, whereas methane from natural gas releases stored carbon.
- Methane from landfill is more carbon neutral, methane from natural gas increases atmospheric CO_2 levels.
- Obtaining methane from natural gas via fracking causes additional significant environmental damage, whereas when obtaining methane from a landfill the damage has already been done in the formation of the landfill.
- Landfill gases contain less methane and release more CO_2 (for the same amount of energy generated), natural gas contains more methane and releases comparatively less CO_2.
- Methane captured from landfill and used as a source on energy may have a positive impact as it is a more potent greenhouse gas than CO_2.
- CH_4 from landfill is more easily collected compared to fracking/sourcing methane from fossil fuels.
- Two marks were awarded for any two valid comparison points.
- Students often made two very good statements, but more frequently than not these did not compare the environmental impact between the two sources. The key word ‘compare’ in the question means that a direct comparison is required to obtain full marks.

Spac

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, CH_3CH_2OH, 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.

Space for Personal Notes

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 biod

C. 38 g of methanol.

D. 12 L of LPG, which cons

A. $n(methane) = 28/24.8 = 1.13\ mol, E = 1.13 \times 890\ 1005\ kJ$
B. $m = 0.13 \times 292 = 37.96\ g, E = 45 \times 37.96 = 1708.2\ kJ$
C. $E = 38 \times 22.7 = 862.6\ kJ$
D. $n(propane) = \frac{4}{24.8} = 0.16\ mol, E(propane) = 0.16 \times 2220 = 358\ kJ$
$n(butane) = 8/24.8 = 0.32\ mol, E(butane) = 0.32 \times 2880 = 929\ kJ$
$E(total) = 359 + 929 = 1288\ kJ$

Space for Personal Notes

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. C_2H_4

B. C_3H_4

C. C_3H_6

D. C_2H_6

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, O_2, 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, H_2

B. 3.95 g of propane, C_3H_8

C. 0.282 mol of methane, CH_4

D. 0.301 mol of methanol, CH_3OH

Energy absorbed by water $= 4.18\ J\ g^{-}1C^{-1}$
$= 4.18 \times 500 \times 0.997 \times 60.0 = 1.25 \times 105J = 125\ kJ$
Consider the options:
Option A: 0.889 g H_2 0.889 $g \times 141\ kJ\ g^{-1}$ 125 kJ
Option B: 3.95 g C_3H_8 3.95 $g \times 50.5\ kJ\ g^{-1}$ 199 kJ
Option C: 0.282 mol CH_4 0.282 $mol \times 890\ kJ\ g^{-1}$ 251 kJ
Option D: 0.301 mol CH_3OH 0.301 $mol \times 726\ kJ\ g^{-1}$ 219 kJ

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	$C_4H_9COOCH_3$	3558
Methyl hexanoate	$C_5H_{11}COOCH_3$	4211
Methyl heptanoate	$C_6H_{13}COOCH_3$	4863

One of the molecules found in biodiesel is methyl stearate, $C_{17}H_{35}COOCH_3$. 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 (CO_2) plants absorb from the air as they grow completely offsets, or "neutralises," the CO_2 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 Voegele, '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.

Marks	0	1	2	3	4	Average
%	20	15	28	26	12	2

Valid discussion points included:

Carbon

- For:
  - CO_2 is absorbed/used by the crops/plants (used to produce the biodiesel)
  - more carbon neutral as biodiesel produces less new CO_2 than other fuels
- Against:
  - use of petroleum diesel (or other fuels) to produce biodiesel – a large amount of energy is required to produce biodiesel fuel from soy crops, as energy is needed for sowing, fertilising, harvesting, transporting and processing crops
  - clearing land for crops by burning trees releases CO_2 and destroys habitats
  - there is less photosynthesis when land is cleared
  - burning biomass directly emits a bit more carbon dioxide than fossil fuels for the same amount of generated energy

Sustainability of using biodiesel as a fuel

- For:
  - plants can be produced/grown in a short period of time
  - can be made from waste vegetable oils, animal fats, or restaurant grease
  - releases fewer toxic chemicals if spilled or released to the environment/many by-products are biodegradable
  - biodiesel produces less soot (particulate matter)/carbon monoxide/unburned hydrocarbons/sulfur dioxide
  - crops (that produce oil) can be grown in many places
  - can use second-generation technologies to convert material such as crop residues into bioenergy and avoid competition for land
- Against:
  - some regions are not suitable for oil producing crops
  - uses crops/land that could be used for food/food production
  - the excess use of fertilisers can result in soil erosion and land pollution
  - nitrous oxide released from fertilisers could have a greater (300 times more) global warming effect than carbon dioxide
  - the use of water to produce more crops can put pressure on local water resources

Using biodiesel as a fuel for transport

- For:
  - produces less toxic pollutants and greenhouse gases than petroleum diesel
  - can be used in any diesel engine with little or no modification to the engine or the fuel system
  - higher flashpoint, which makes it less combustible and therefore safer to handle, store and transport
  - the lubricating property of the biodiesel may lengthen the lifetime of engines
- Against:
  - higher viscosity/not suitable for use in low temperatures
  - biodiesel fuel is more expensive than petroleum diesel fuel.

Two marks were awarded for at least two valid points for, two valid points against, or one valid point for and one valid point against carbon neutrality related to biodiesel. The same was awarded for sustainability related to biodiesel.

OR

One mark for at least one valid point (for or against) regarding sustainability related to biodiesel.

One mark for at least one valid point (for or against) regarding carbon neutrality related to biodiesel.

One mark for at least one valid point (for or against) use of biodiesel as a fuel.

One mark for a second valid point (for or against) one of carbon neutrality, sustainability, use as a fuel.

Sixty-five per cent of students obtained two or more marks, although many did not fully explain why biofuels were carbon neutral or renewable. Some who tried to incorporate the media statements did so without really making headway in explanation. There was evidence that time pressure affected some students.

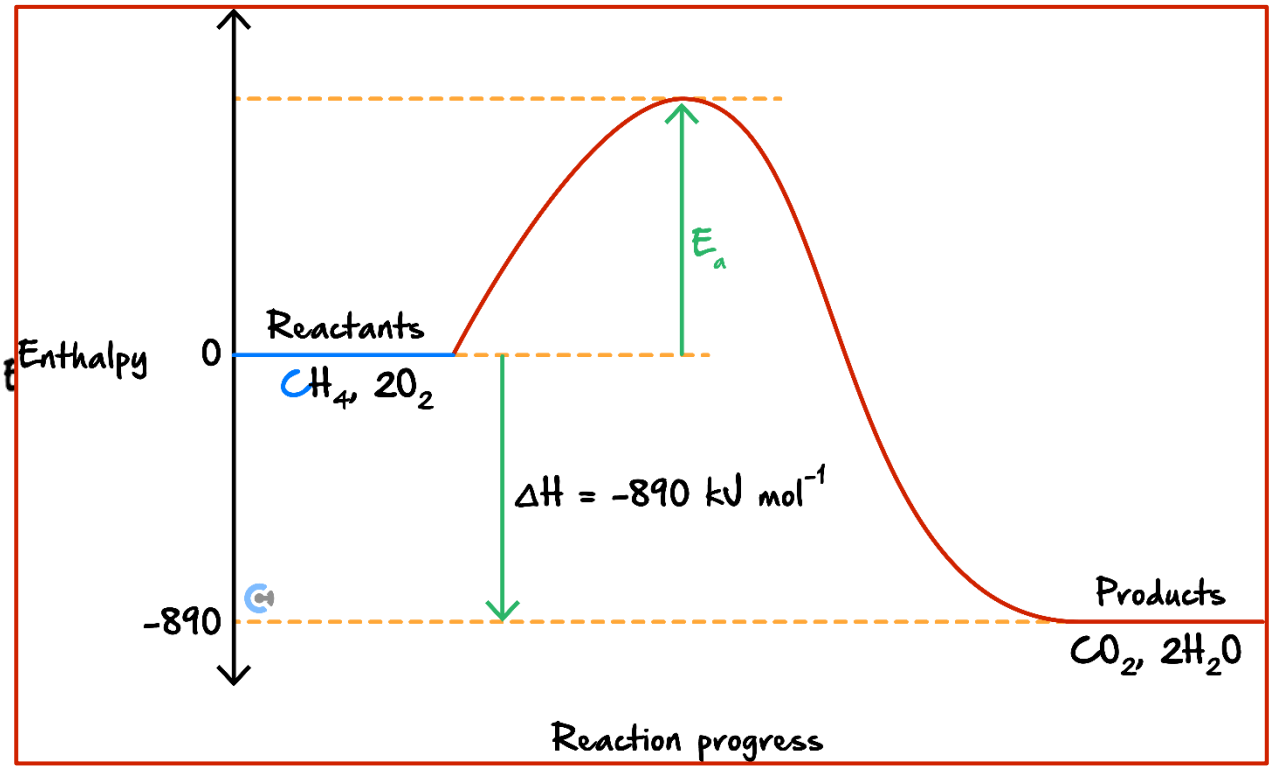
Question 20 (10 marks)

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)

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$; $\Delta H =$ $-890\ kJ/mol$

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)

$m(CH_4) = 0.78 \times 100$

$= 78.0$ kg

$n(CH_4) = 78.0 \times 10^3/16.0$

$= 4.88 \times 10^2$ mol

Energy available = 4.88×10^2 mol × 889 kJ mol^{-1}

4.34×10^6

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

Advantage:

- Biogas is a renewable energy source.
- Biogas can be produced from agricultural waste.
- Reduces atmospheric CH_4 from waste agricultural waste decay.

Disadvantage:

- CO_2 produced in combustion is a greenhouse gas.
- $H_2O(g)$ produced is a greenhouse gas.
- Since biogas is only 78% methane, other pollutants such as $SO_2(g)$ may be produced during its combustion.

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 selectio

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.

Option A is incorrect. Diesel generators produce CO_2 and a range of other pollutants.

Option B is incorrect as diesel is a petroleum product that is non-renewable.

Option C is incorrect. Many galvanic cells and fuel cells will be more efficient than a diesel generator.

Option D is correct. If demand for electrical energy is unexpectedly high, the diesel generators can be switched on to meet this demand very quickly.

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. $C_{38}H_{78}$

Option A is correct. Alkanes have the general formula C_nH_{2n+2}. For the alkane molecule to have 38 atoms, the formula must be $C_{12}H_{26}$.

Option B is incorrect. It is an alkene.

Option C is incorrect as it contains too many atoms.

Option D is incorrect as it contains too many atoms.

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 sedimen

C. Fossil fuels, biofuels, oil trapped in rock formations.

D. Biogas, bioethanol, diesel composed of methyl esters.

The renewable resources are:

A – methane gas generated in a digester

B – none

C – biofuels

D – biogas, bioethanol, diesel composed of methyl esters

CONTOUREDUCATION

Website: contoureducation.com.au | **Phone:** 1800 888 300 | **Email:** hello@contoureducation.com.au

VCE Chemistry ¾

Free 1-on-1 Support

Be Sure to Make The Most of These (Free) Services!

- Experienced Contour tutors (45+ raw scores, 99+ ATARs).
- For fully enrolled Contour students with up-to-date fees.
- After school weekdays and all-day weekends.

1-on-1 Video Consults	Text-Based Support
➢ Book via bit.ly/contour-chemistry-consult-2025 (or QR code below). ➢ One active booking at a time (must attend before booking the next).	➢ Message +61 440 137 304 with questions. ➢ Save the contact as "Contour Chemistry".

Booking Link for Consults
bit.ly/contour-chemistry-consult-2025

Number for Text-Based Support
+61 440 137 304