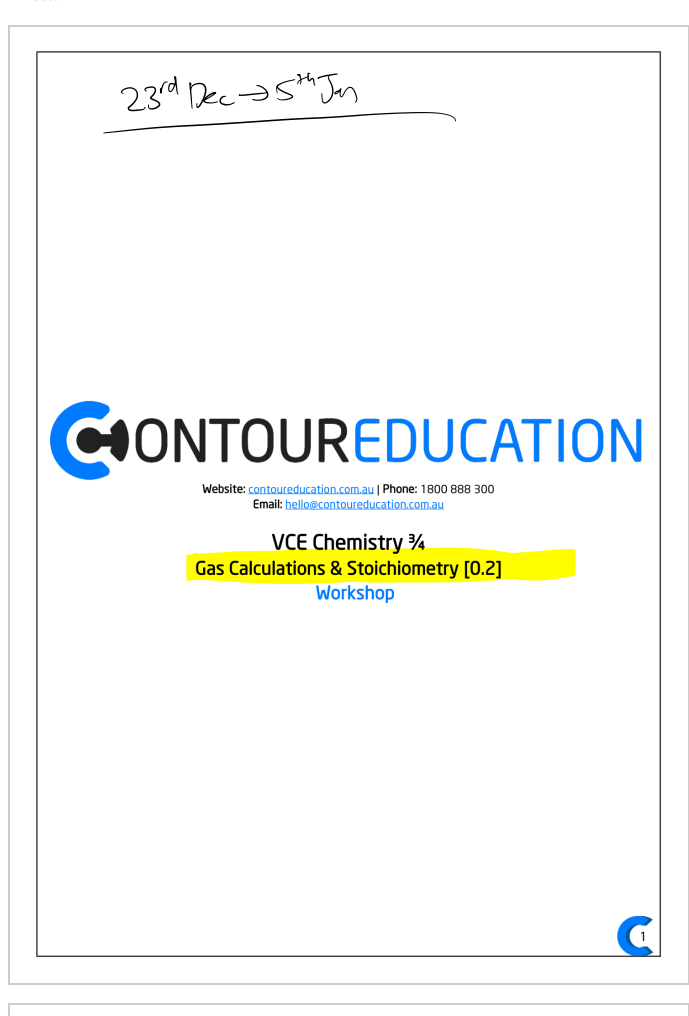
CH34 [0.2] - Gas Calculations _ Stoichiometry - Workshop

Sunday 15 December 2024 5:55 PM

CH34 [0.2] - Gas...

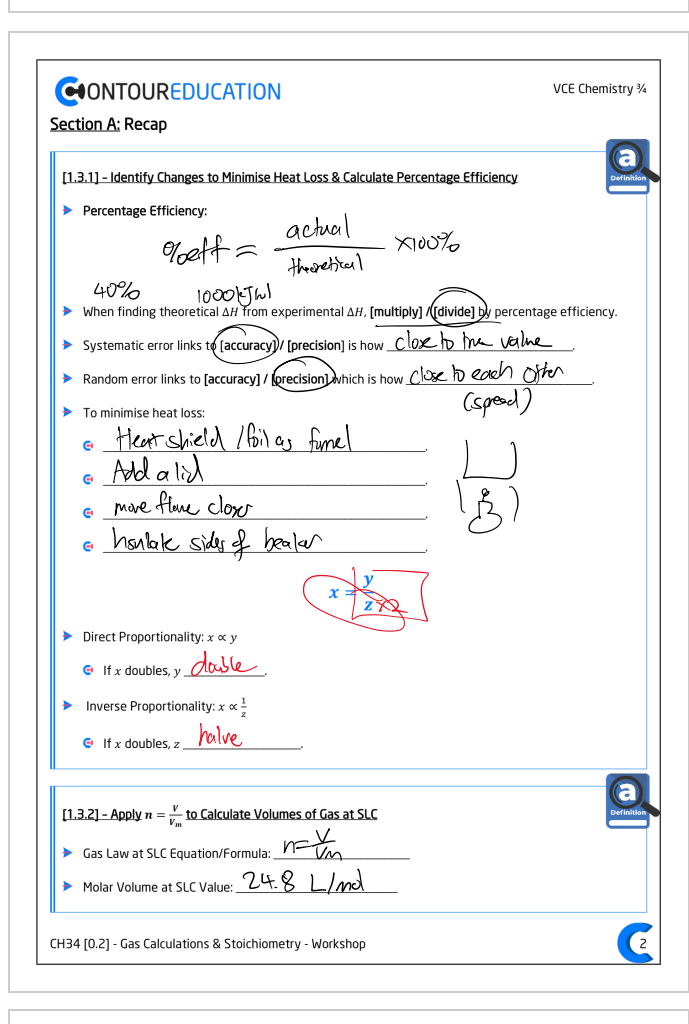


23rd Dec → 5th Jan

CONTOUREDUCATION

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

VCE Chemistry ¾
Gas Calculations & Stoichiometry [0.2]
Workshop



Section A: Recap

[1.3.1] - Identify Changes to Minimise Heat Loss & Calculate Percentage Efficiency

- Percentage Efficiency: $\%eff = \frac{actual}{theoretical} \times 100\%$

40% 1000 kJ/ml

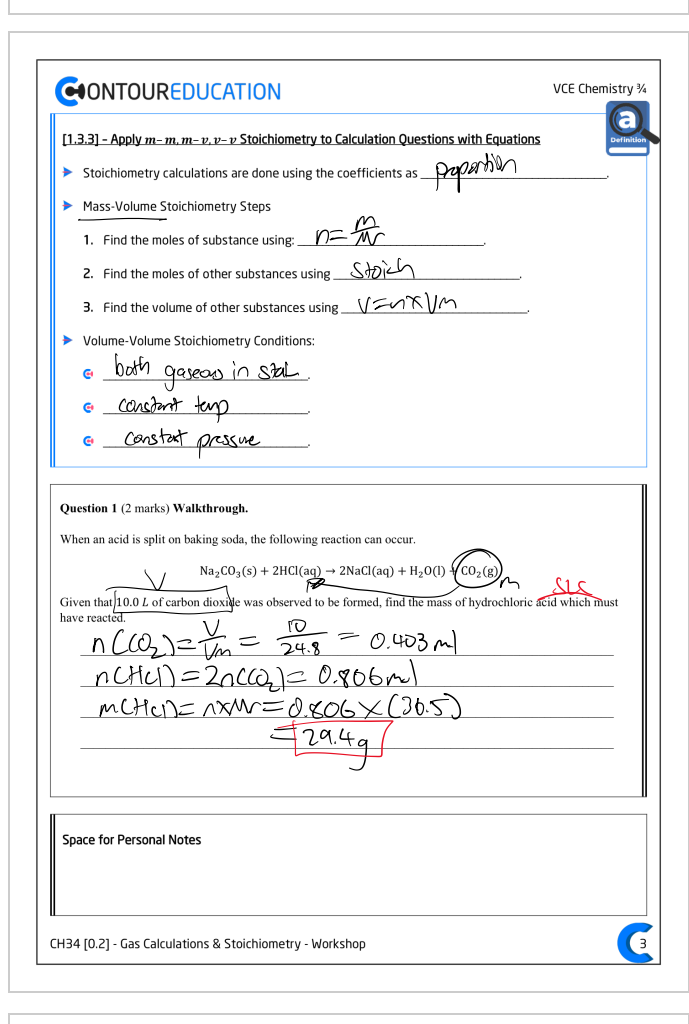
- When finding theoretical ΔH from experimental ΔH, [multiply] / [divide] by percentage efficiency.
- Systematic error links to [accuracy] / [precision] is how close to true value.
- Random error links to [accuracy] / [precision] which is how close to each other (spread).
- To minimise heat loss:
  - Heat shield / foil as funnel
  - Add a lid
  - move flame closer
  - Insulate sides of beaker

$x = \frac{y}{z}$

- Direct Proportionality: $x \propto y$
  - If x doubles, y double.
- Inverse Proportionality: $x \propto \frac{1}{z}$
  - If x doubles, z halve.

[1.3.2] - Apply $n = \frac{V}{V_m}$ to Calculate Volumes of Gas at SLC

- Gas Law at SLC Equation/Formula: $n = \frac{V}{V_m}$
- Molar Volume at SLC Value: 24.8 L/mol



[1.3.3] - Apply $m-m$, $m-v$, $v-v$ Stoichiometry to Calculation Questions with Equations

- Stoichiometry calculations are done using the coefficients as proportion.
- Mass-Volume Stoichiometry Steps
  1. Find the moles of substance using: $n = \frac{m}{M_r}$
  2. Find the moles of other substances using Stoich
  3. Find the volume of other substances using $V = n \times V_m$
- Volume-Volume Stoichiometry Conditions:
  - both gaseous in SLC
  - constant temp
  - constant pressure

Question 1 (2 marks) **Walkthrough.**

When an acid is spilt on baking soda, the following reaction can occur.

$$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$$

Given that 10.0 L of carbon dioxide was observed to be formed, find the mass of hydrochloric acid which must have reacted.

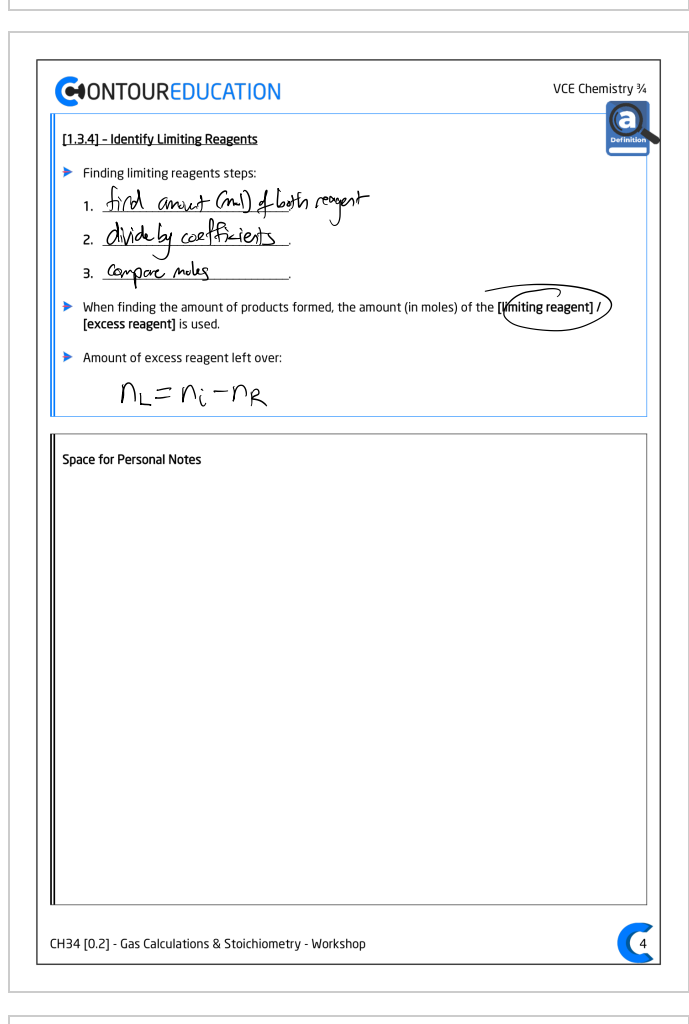
$n(CO_2) = \frac{V}{V_m} = \frac{10}{24.8} = 0.403\ mol$

$n(HCl) = 2n(CO_2) = 0.806\ mol$

$m(HCl) = n \times M_r = 0.806 \times (36.5)$

$= \boxed{29.4\ g}$

Space for Personal Notes

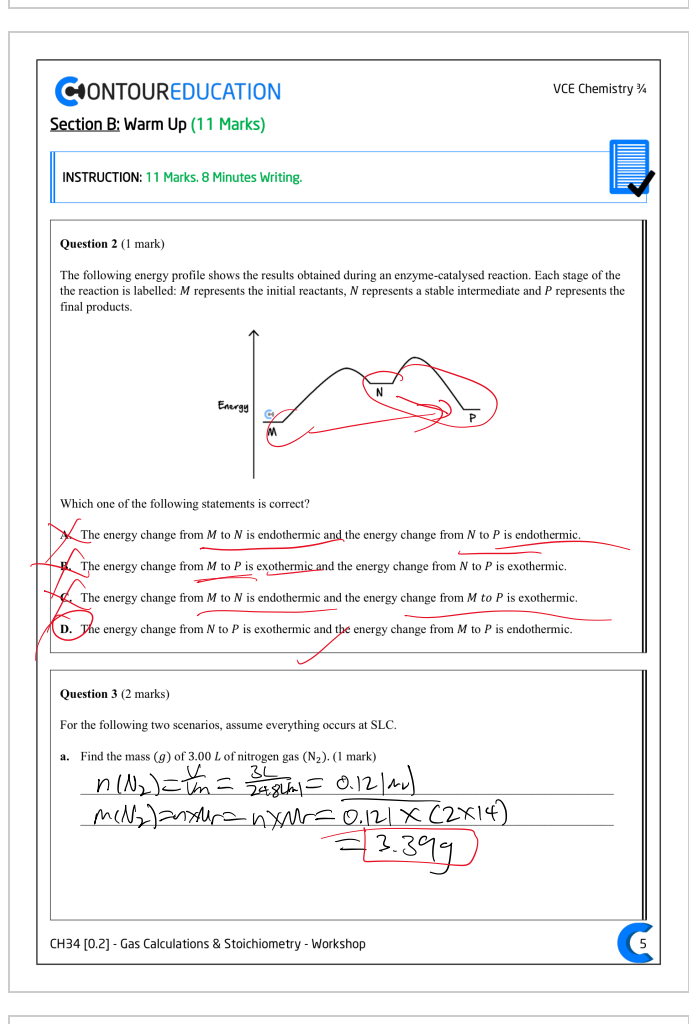


[1.3.4] - Identify Limiting Reagents

- Finding limiting reagents steps:
  1. find amount (mol) of both reagent
  2. divide by coefficients
  3. compare moles
- When finding the amount of products formed, the amount (in moles) of the [limiting reagent] / [excess reagent] is used.
- Amount of excess reagent left over:

$n_L = n_i - n_R$

Space for Personal Notes



Section B: Warm Up (11 Marks)

INSTRUCTION: 11 Marks. 8 Minutes Writing.

Question 2 (1 mark)

The following energy profile shows the results obtained during an enzyme-catalysed reaction. Each stage of the reaction is labelled: M represents the initial reactants, N represents a stable intermediate and P represents the final products.

Which one of the following statements is correct?

A. The energy change from M to N is endothermic and the energy change from N to P is endothermic.
B. The energy change from M to P is exothermic and the energy change from N to P is exothermic.
C. The energy change from M to N is endothermic and the energy change from M to P is exothermic.
D. The energy change from N to P is exothermic and the energy change from M to P is endothermic.

Question 3 (2 marks)

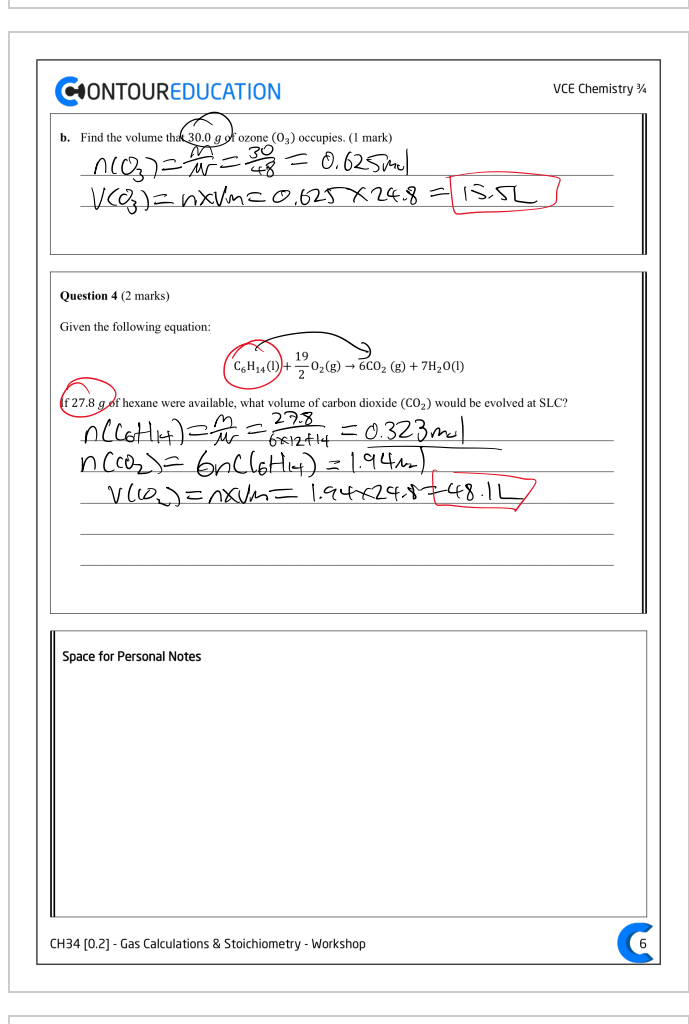
For the following two scenarios, assume everything occurs at SLC.

a. Find the mass (g) of 3.00 L of nitrogen gas (N_2). (1 mark)

$n(N_2) = \frac{V}{V_m} = \frac{3}{24.8} = 0.121\ mol$

$m(N_2) = n \times M_r = 0.121 \times (2 \times 14)$

$= \boxed{3.39\ g}$



b. Find the volume that 30.0 g of ozone (O_3) occupies. (1 mark)

$n(O_3) = \frac{m}{M_r} = \frac{30}{48} = 0.625\ mol$

$V(O_3) = n \times V_m = 0.625 \times 24.8 = \boxed{15.5\ L}$

Question 4 (2 marks)

Given the following equation:

$$C_6H_{14}(l) + \frac{19}{2}O_2(g) \rightarrow 6CO_2(g) + 7H_2O(l)$$

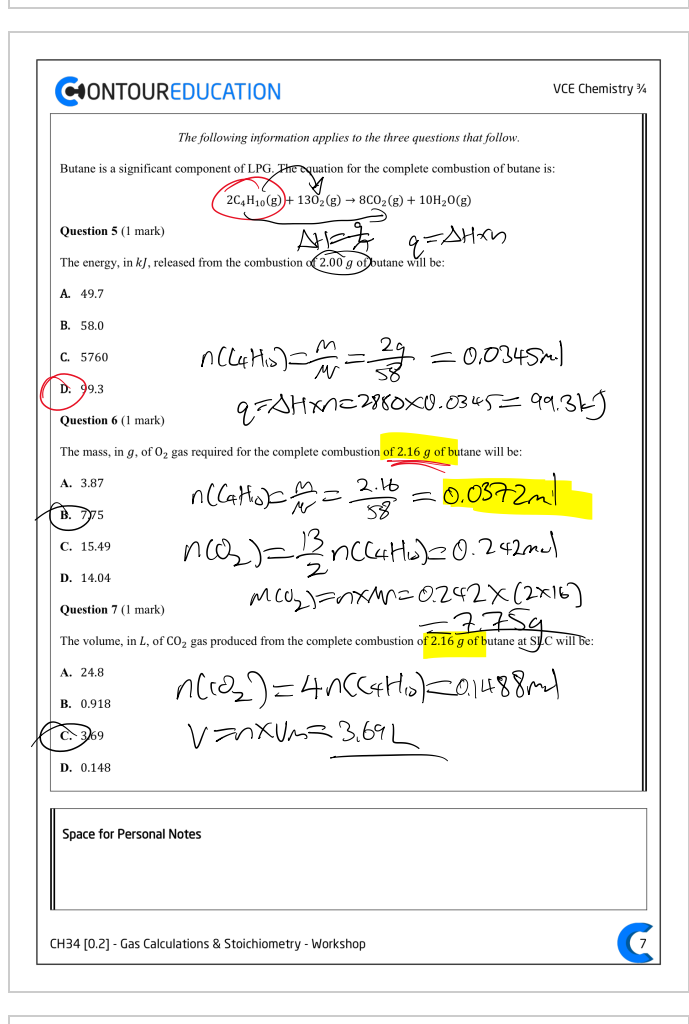
If 27.8 g of hexane were available, what volume of carbon dioxide (CO_2) would be evolved at SLC?

$n(C_6H_{14}) = \frac{m}{M_r} = \frac{27.8}{6 \times 12 + 14} = 0.323\ mol$

$n(CO_2) = 6n(C_6H_{14}) = 1.94\ mol$

$V(CO_2) = n \times V_m = 1.94 \times 24.8 = \boxed{48.1\ L}$

Space for Personal Notes



The following information applies to the three questions that follow.

Butane is a significant component of LPG. The equation for the complete combustion of butane is:

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)$$

$\Delta H = \frac{q}{n}$ $q = \Delta H \times n$

Question 5 (1 mark)

The energy, in kJ, released from the combustion of 2.00 g of butane will be:

A. 49.7
B. 58.0
C. 5760
D. 99.3

$n(C_4H_{10}) = \frac{m}{M_r} = \frac{2}{58} = 0.0345\ mol$

$q = \Delta H \times n = 2880 \times 0.0345 = 99.3\ kJ$

Question 6 (1 mark)

The mass, in g, of O_2 gas required for the complete combustion of 2.16 g of butane will be:

A. 3.87
B. 7.75
C. 15.49
D. 14.04

$n(C_4H_{10}) = \frac{m}{M_r} = \frac{2.16}{58} = 0.0372\ mol$

$n(O_2) = \frac{13}{2} n(C_4H_{10}) = 0.242\ mol$

$m(O_2) = n \times M_r = 0.242 \times (2 \times 16)$

$= 7.75\ g$

Question 7 (1 mark)

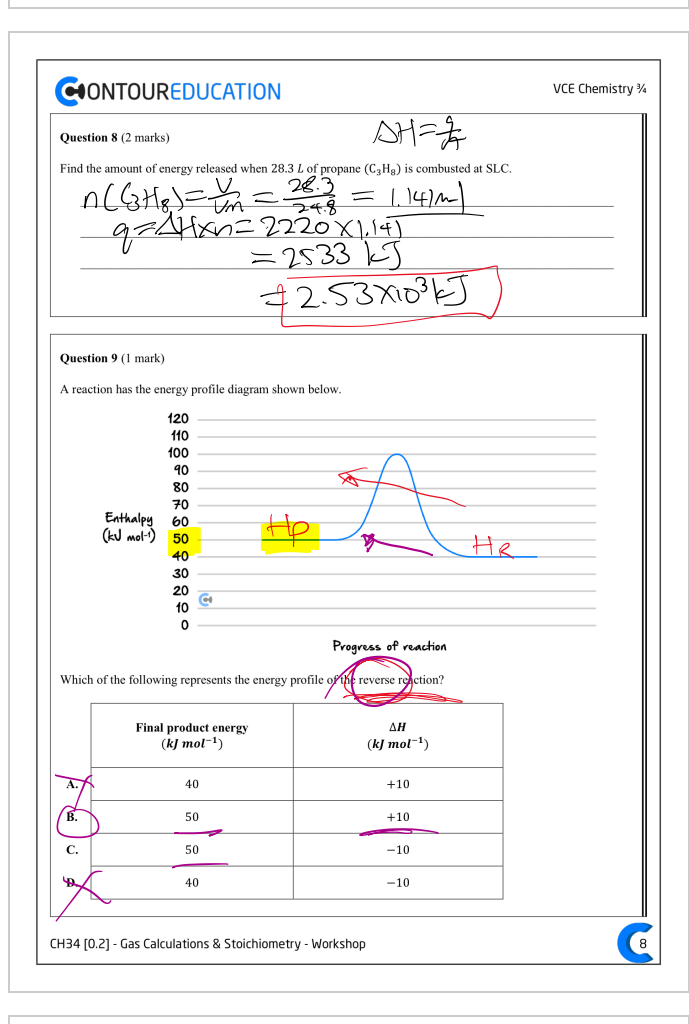
The volume, in L, of CO_2 gas produced from the complete combustion of 2.16 g of butane at SLC will be:

A. 24.8
B. 0.918
C. 3.69
D. 0.148

$n(CO_2) = 4n(C_4H_{10}) = 0.1488\ mol$

$V = n \times V_m = 3.69\ L$

Space for Personal Notes



Question 8 (2 marks) $\Delta H = \frac{q}{n}$

Find the amount of energy released when 28.3 L of propane (C_3H_8) is combusted at SLC.

$n(C_3H_8) = \frac{V}{V_m} = \frac{28.3}{24.8} = 1.14\ mol$

$q = \Delta H \times n = 2220 \times 1.14$

$= 2533\ kJ$

$= \boxed{2.53 \times 10^3\ kJ}$

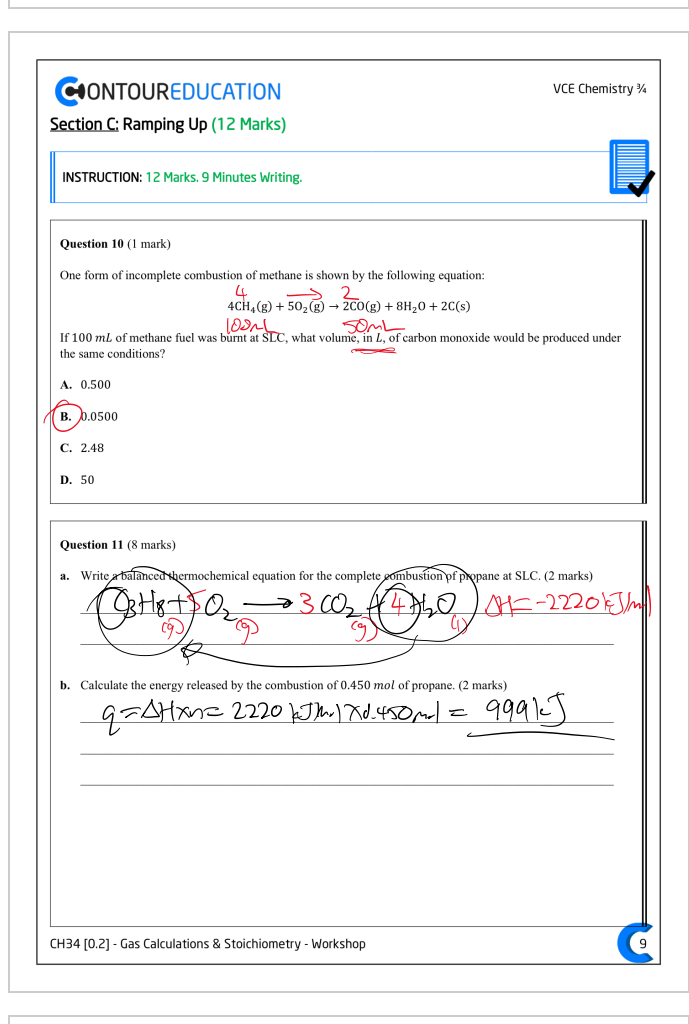
Question 9 (1 mark)

A reaction has the energy profile diagram shown below.

Enthalpy (kJ mol⁻¹)
120
110
100
90
80
70
60
50
40
30
20
10
0
Progress of reaction
Hp
Hr

Which of the following represents the energy profile of the reverse reaction?

	Final product energy ($kJ\ mol^{-1}$)	ΔH ($kJ\ mol^{-1}$)
A.	40	+10
B.	50	+10
C.	50	−10
D.	40	−10



Section C: Ramping Up (12 Marks)

INSTRUCTION: 12 Marks. 9 Minutes Writing.

Question 10 (1 mark)

One form of incomplete combustion of methane is shown by the following equation:

$$\overset{4}{4CH_4(g)} + 5O_2(g) \rightarrow \overset{2}{2CO(g)} + 8H_2O + 2C(s)$$

If 100 mL of methane fuel was burnt at SLC, what volume, in L, of carbon monoxide would be produced under the same conditions?

100mL   50mL

A. 0.500
B. 0.0500
C. 2.48
D. 50

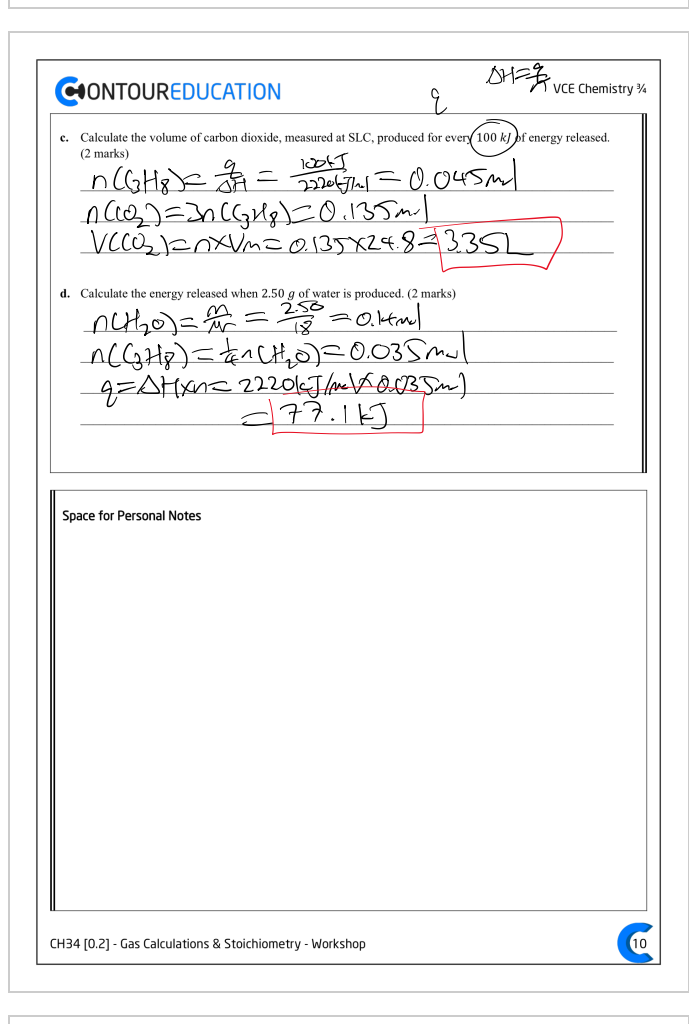
Question 11 (8 marks)

a. Write a balanced thermochemical equation for the complete combustion of propane at SLC. (2 marks)

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l) \quad \Delta H = -2220\ kJ/mol$

b. Calculate the energy released by the combustion of 0.450 mol of propane. (2 marks)

$q = \Delta H \times n = 2220\ kJ/mol \times 0.450\ mol = 999\ kJ$



$\Delta H = \frac{q}{n}$

c. Calculate the volume of carbon dioxide, measured at SLC, produced for every 100 kJ of energy released. (2 marks)

$n(C_3H_8) = \frac{q}{\Delta H} = \frac{100\ kJ}{2220\ kJ/mol} = 0.045\ mol$

$n(CO_2) = 3n(C_3H_8) = 0.135\ mol$

$V(CO_2) = n \times V_m = 0.135 \times 24.8 = \boxed{3.35\ L}$

d. Calculate the energy released when 2.50 g of water is produced. (2 marks)

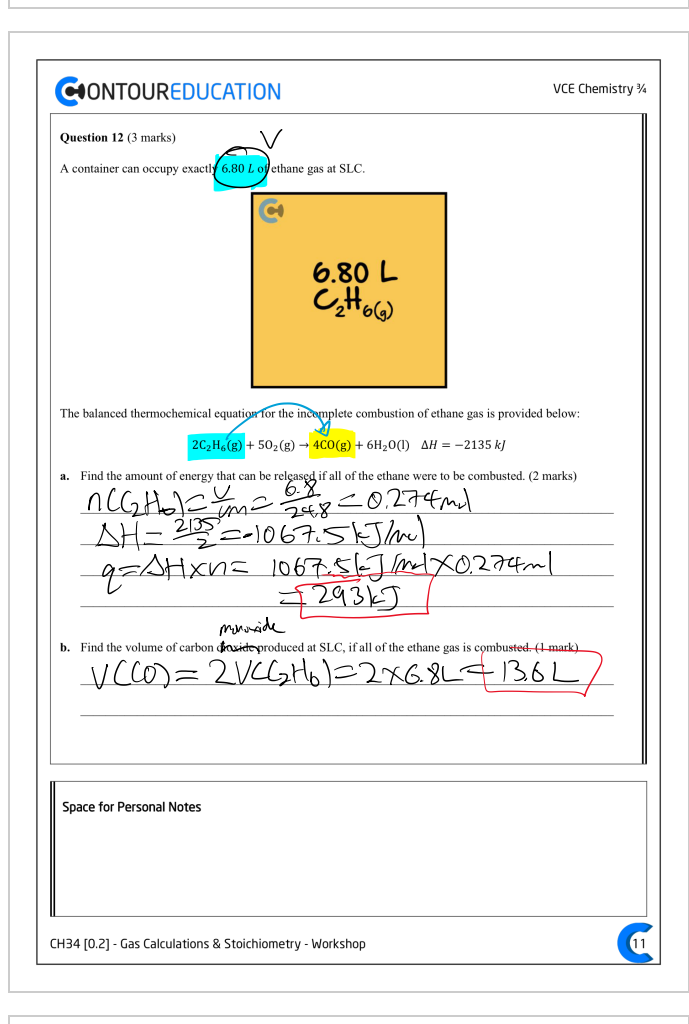
$n(H_2O) = \frac{m}{M_r} = \frac{2.50}{18} = 0.14\ mol$

$n(C_3H_8) = \frac{1}{4} n(H_2O) = 0.035\ mol$

$q = \Delta H \times n = 2220\ kJ/mol \times 0.035\ mol$

$= \boxed{77.1\ kJ}$

Space for Personal Notes



Question 12 (3 marks)

A container can occupy exactly 6.80 L of ethane gas at SLC.

The balanced thermochemical equation for the incomplete combustion of ethane gas is provided below:

$$2C_2H_6(g) + 5O_2(g) \rightarrow 4CO(g) + 6H_2O(l) \quad \Delta H = -2135\ kJ$$

a. Find the amount of energy that can be released if all of the ethane were to be combusted. (2 marks)

$n(C_2H_6) = \frac{V}{V_m} = \frac{6.8}{24.8} = 0.274\ mol$

$\Delta H = \frac{2135}{2} = 1067.5\ kJ/mol$

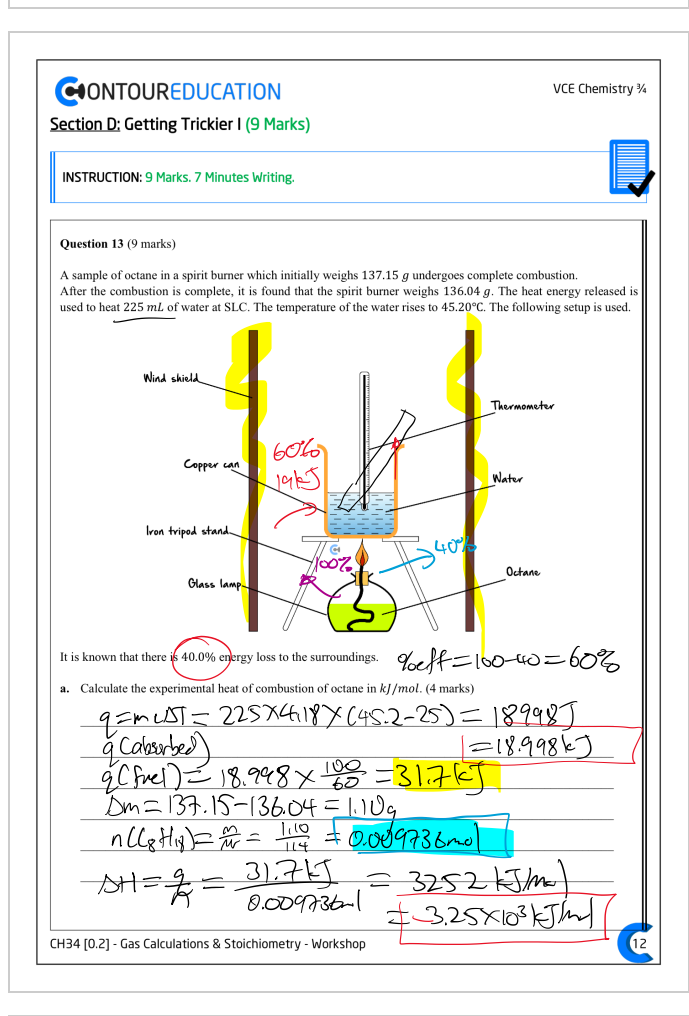
$q = \Delta H \times n = 1067.5\ kJ/mol \times 0.274\ mol$

$= \boxed{293\ kJ}$

b. Find the volume of carbon ~~dioxide~~ monoxide produced at SLC, if all of the ethane gas is combusted. ~~(1 mark)~~

$V(CO) = 2V(C_2H_6) = 2 \times 6.8\ L = \boxed{13.6\ L}$

Space for Personal Notes



Section D: Getting Trickier I (9 Marks)

INSTRUCTION: 9 Marks. 7 Minutes Writing.

Question 13 (9 marks)

A sample of octane in a spirit burner which initially weighs 137.15 g undergoes complete combustion. After the combustion is complete, it is found that the spirit burner weighs 136.04 g. The heat energy released is used to heat 225 mL of water at SLC. The temperature of the water rises to 45.20°C. The following setup is used.

It is known that there is 40.0% energy loss to the surroundings. $\%eff = 100 - 40 = 60\%$

a. Calculate the experimental heat of combustion of octane in kJ/mol. (4 marks)

$q = mc\Delta T = 225 \times 4.18 \times (45.2 - 25) = 18998\ J$

$q(absorbed) = 18.998\ kJ$

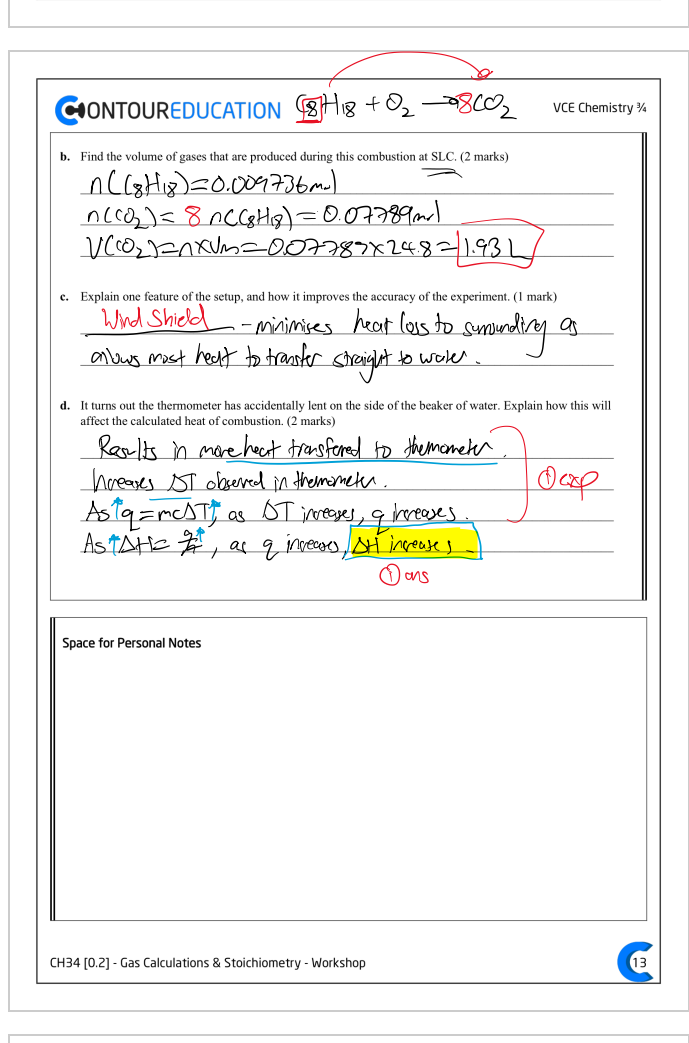
$q(fuel) = 18.998 \times \frac{100}{60} = 31.7\ kJ$

$\Delta m = 137.15 - 136.04 = 1.10\ g$

$n(C_8H_{18}) = \frac{m}{M_r} = \frac{1.10}{114} = 0.009736\ mol$

$\Delta H = \frac{q}{n} = \frac{31.7\ kJ}{0.009736\ mol} = 3252\ kJ/mol$

$= \boxed{3.25 \times 10^3\ kJ/mol}$



$C_8H_{18} + O_2 \rightarrow 8CO_2$

b. Find the volume of gases that are produced during this combustion at SLC. (2 marks)

$n(C_8H_{18}) = 0.009736\ mol$

$n(CO_2) = 8n(C_8H_{18}) = 0.07789\ mol$

$V(CO_2) = n \times V_m = 0.07789 \times 24.8 = \boxed{1.93\ L}$

c. Explain one feature of the setup, and how it improves the accuracy of the experiment. (1 mark)

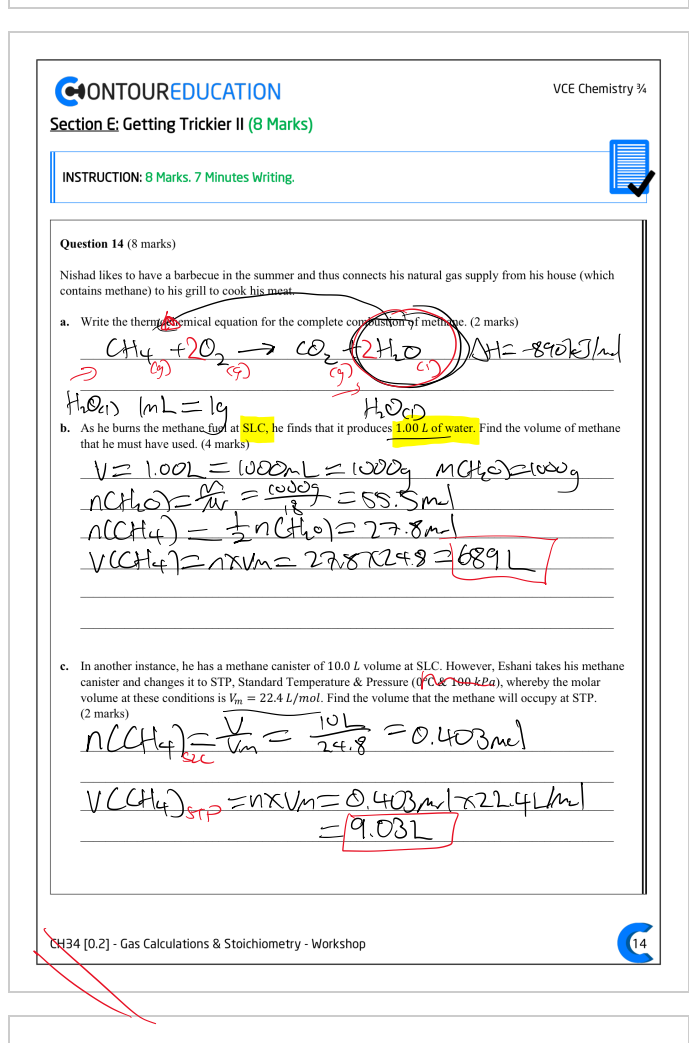
Wind Shield - minimises heat loss to surrounding & allows most heat to transfer straight to water.

d. It turns out the thermometer has accidentally lent on the side of the beaker of water. Explain how this will affect the calculated heat of combustion. (2 marks)

Results in more heat transferred to thermometer.
Increases ΔT observed in thermometer.
As $q = mc\Delta T$, as ΔT increases, q increases.
As $\Delta H = \frac{q}{n}$, as q increases, ΔH increases.

① exp
① ans

Space for Personal Notes



Section E: Getting Trickier II (8 Marks)

INSTRUCTION: 8 Marks. 7 Minutes Writing.

Question 14 (8 marks)

Nishad likes to have a barbecue in the summer and thus connects his natural gas supply from his house (which contains methane) to his grill to cook his meat.

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

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

$H_2O(l)$ 1 mL = 1 g $H_2O(l)$

b. As he burns the methane fuel at SLC, he finds that it produces 1.00 L of water. Find the volume of methane that he must have used. (4 marks)

$V = 1.00\ L = 1000\ mL = 1000\ g \quad m(H_2O) = 1000\ g$

$n(H_2O) = \frac{m}{M_r} = \frac{1000}{18} = 55.5\ mol$

$n(CH_4) = \frac{1}{2} n(H_2O) = 27.8\ mol$

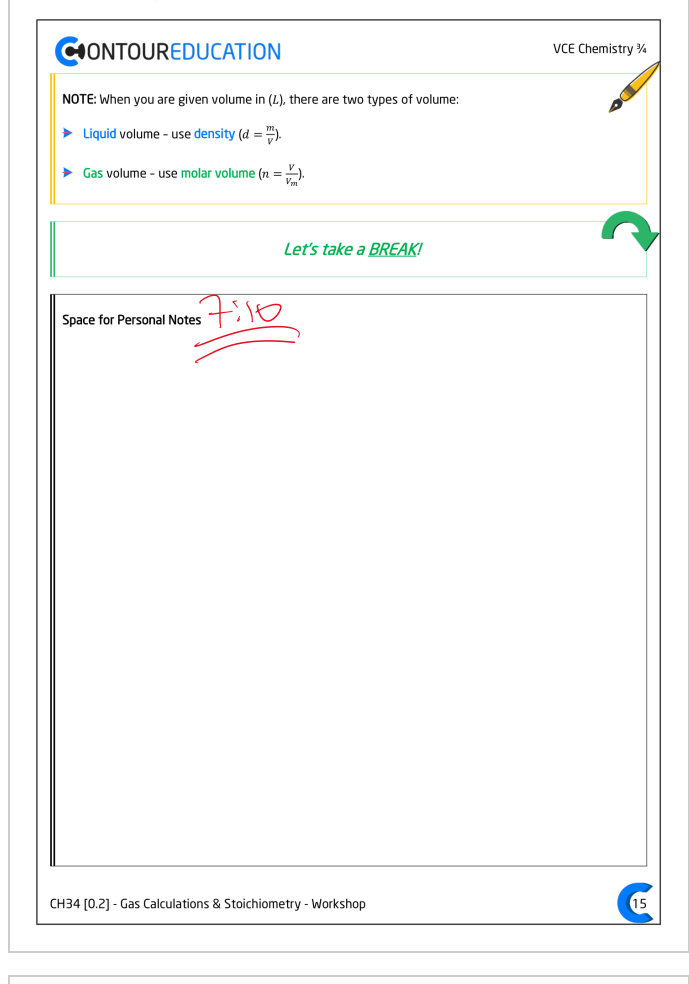
$V(CH_4) = n \times V_m = 27.8 \times 24.8 = \boxed{689\ L}$

c. In another instance, he has a methane canister of 10.0 L volume at SLC. However, Eshani takes his methane canister and changes it to STP, Standard Temperature & Pressure (0°C and 100 kPa), whereby the molar volume at these conditions is $V_m = 22.4\ L/mol$. Find the volume that the methane will occupy at STP. (2 marks)

$n(CH_4)_{SLC} = \frac{V}{V_m} = \frac{10}{24.8} = 0.403\ mol$

$V(CH_4)_{STP} = n \times V_m = 0.403\ mol \times 22.4\ L/mol$

$= \boxed{9.03\ L}$

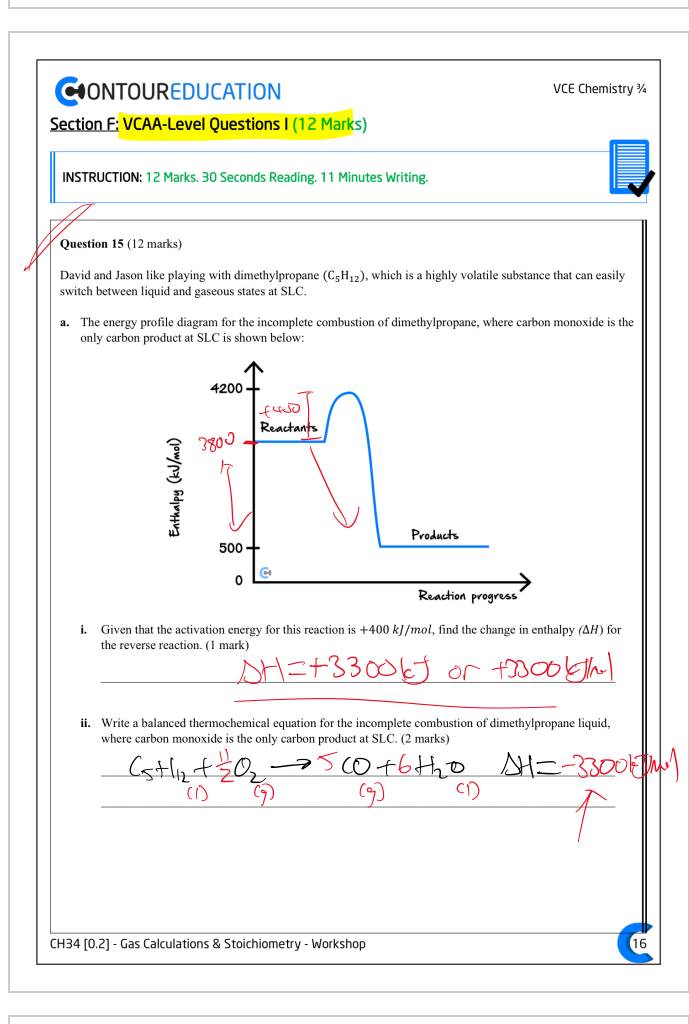


NOTE: When you are given volume in (L), there are two types of volume:

- Liquid volume - use density ($d = \frac{m}{V}$).
- Gas volume - use molar volume ($n = \frac{V}{V_m}$).

Let's take a BREAK!

Space for Personal Notes 7:10



Section F: VCAA-Level Questions I (12 Marks)

INSTRUCTION: 12 Marks. 30 Seconds Reading. 11 Minutes Writing.

Question 15 (12 marks)

David and Jason like playing with dimethylpropane (C_5H_{12}), which is a highly volatile substance that can easily switch between liquid and gaseous states at SLC.

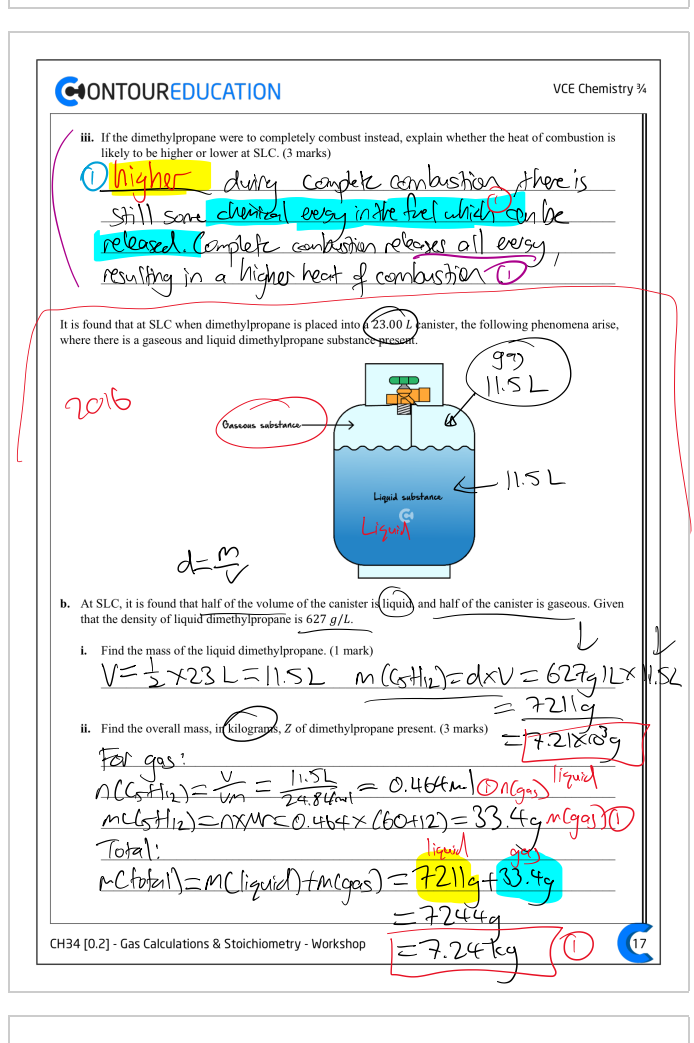
a. The energy profile diagram for the incomplete combustion of dimethylpropane, where carbon monoxide is the only carbon product at SLC is shown below:

i. Given that the activation energy for this reaction is +400 kJ/mol, find the change in enthalpy (ΔH) for the reverse reaction. (1 mark)

$\Delta H = +3300\ kJ$ or $+3300\ kJ/mol$

ii. Write a balanced thermochemical equation for the incomplete combustion of dimethylpropane liquid, where carbon monoxide is the only carbon product at SLC. (2 marks)

$C_5H_{12}(l) + \frac{11}{2}O_2(g) \rightarrow 5CO(g) + 6H_2O(l) \quad \Delta H = -3300\ kJ/mol$



iii. If the dimethylpropane were to be completely combust instead, explain whether the heat of combustion is likely to be higher or lower at SLC. (3 marks)

① higher, during complete combustion, there is still some chemical energy in the fuel which can be released. Complete combustion releases all energy, resulting in a higher heat of combustion ①

It is known that at SLC when dimethylpropane is placed into a 23.0 L canister, the following phenomena arise, where there is a gaseous and liquid dimethylpropane substance present.

7:16

$d = \frac{m}{V}$

b. At SLC, it is found that half of the volume of the canister is liquid, and half of the canister is gaseous. Given that the density of liquid dimethylpropane is 627 g/L.

i. Find the mass of the liquid dimethylpropane. (1 mark)

$V = \frac{1}{2} \times 23\ L = 11.5\ L \quad m(C_5H_{12}) = d \times V = 627\ g/L \times 11.5\ L$

$= 7211\ g$

ii. Find the overall mass, in kilograms, Z of dimethylpropane present. (3 marks)

$= 7.21 \times 10^3\ g$

For gas:

$n(C_5H_{12}) = \frac{V}{V_m} = \frac{11.5}{24.8} = 0.464\ mol$ ① n(gas)

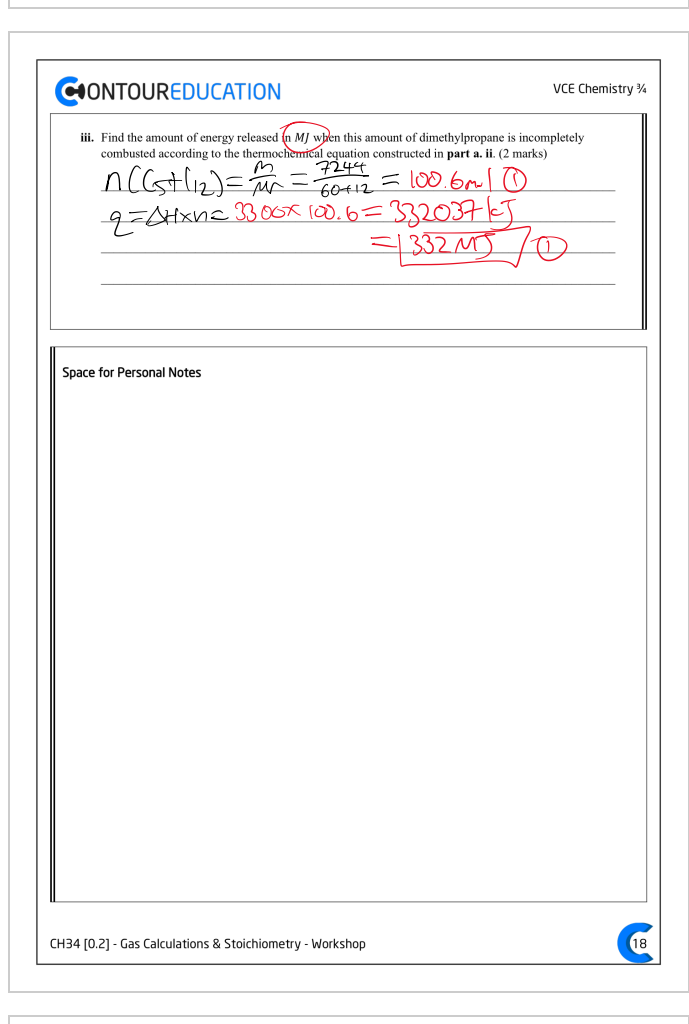
$m(C_5H_{12}) = n \times M_r = 0.464 \times (60 + 12) = 33.4\ g$ m(gas) ①

Total:

$m(total) = m(liquid) + m(gas) = 7211\ g + 33.4\ g$

$= 7244\ g$

$= \boxed{7.24\ kg}$ ①



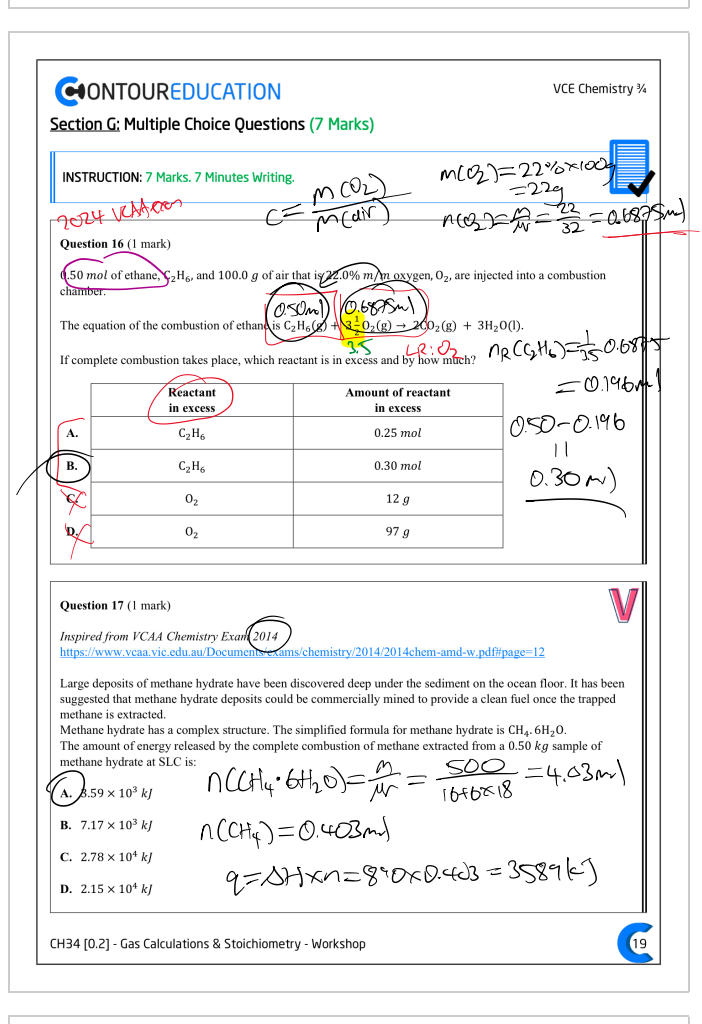
iii. Find the amount of energy released in MJ when this amount of dimethylpropane is incompletely combusted according to the thermochemical equation constructed in part a. ii. (2 marks)

$n(C_5H_{12}) = \frac{m}{M_r} = \frac{7244}{60 + 12} = 100.6\ mol$ ①

$q = \Delta H \times n = 3300 \times 100.6 = 332037\ kJ$

$= \boxed{332\ MJ}$ ①

Space for Personal Notes



Section G: Multiple Choice Questions (7 Marks)

INSTRUCTION: 7 Marks. 7 Minutes Writing.

7:24 [illegible]

$C = \frac{m(O_2)}{m(air)}$ $m(O_2) = 22\% \times 100\ g = 22\ g$ $n(O_2) = \frac{22}{32} = 0.6875\ mol$

Question 16 (1 mark)

0.50 mol of ethane, C_2H_6, and 100.0 g of air that is 22.0% m/m oxygen, O_2, are injected into a combustion chamber.

The equation of the combustion of ethane is $C_2H_6(g) + \frac{7}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$.

If complete combustion takes place, which reactant is in excess and by how much?

$n_R(C_2H_6) = \frac{1}{3.5} \times 0.6875 = 0.196\ mol$

$0.50 - 0.196 = 0.30\ mol$

	Reactant in excess	Amount of reactant in excess
A.	C_2H_6	0.25 mol
B.	C_2H_6	0.30 mol
C.	O_2	12 g
D.	O_2	97 g

Question 17 (1 mark)

Inspired from VCAA Chemistry Exam 2014
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2014/2014chem-and-w.pdf#page=12

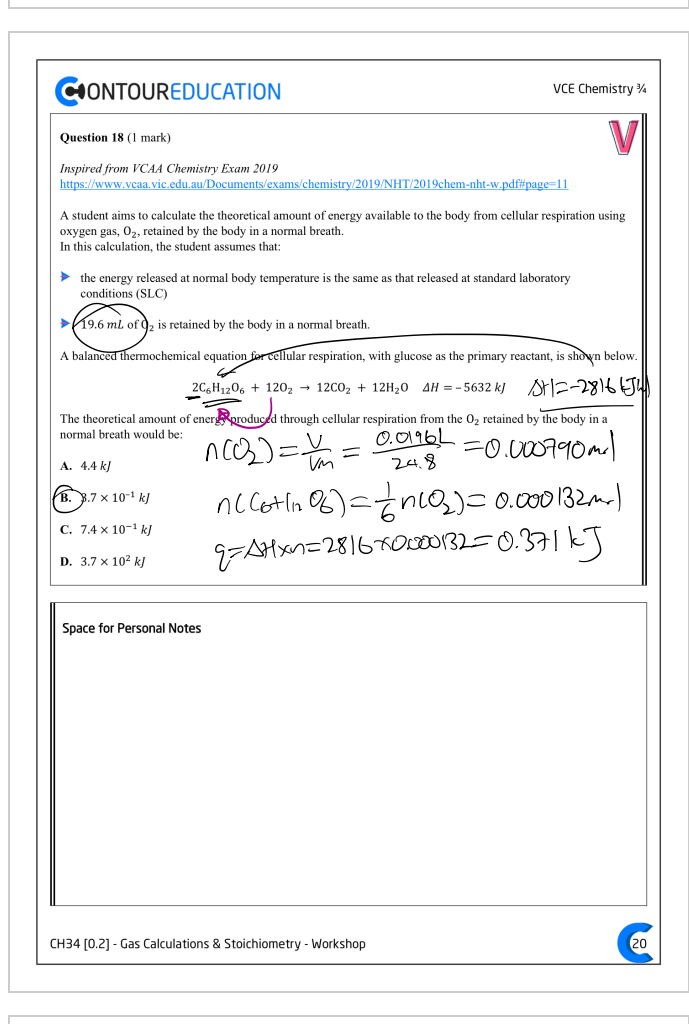
Large deposits of methane hydrate have been discovered deep under the sediment on the ocean floor. It has been suggested that methane hydrate deposits could be commercially mined to provide a clean fuel once the trapped methane is extracted.
Methane hydrate has a complex structure. The simplified formula for methane hydrate is $CH_4 \cdot 6H_2O$.
The amount of energy released by the complete combustion of methane from a 0.50 kg sample of methane hydrate at SLC is:

A. $3.59 \times 10^3\ kJ$
B. $7.17 \times 10^3\ kJ$
C. $2.78 \times 10^4\ kJ$
D. $2.15 \times 10^4\ kJ$

$n(CH_4 \cdot 6H_2O) = \frac{m}{M_r} = \frac{500}{16 + 6 \times 18} = 4.03\ mol$

$n(CH_4) = 0.403\ mol$

$q = \Delta H \times n = 890 \times 0.403 = 3589\ kJ$



Question 18 (1 mark)

Inspired from VCAA Chemistry Exam 2019
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2019/NHT-2019chem-nht-w.pdf#page=11

A student aims to calculate the theoretical amount of energy available to the body from cellular respiration using oxygen gas, O_2, retained by the body in a normal breath.
In this calculation, the student assumes that:

- the energy released at normal body temperature is the same as that released at standard laboratory conditions (SLC)
- 19.6 mL of O_2 is retained by the body in a normal breath.

A balanced thermochemical equation for cellular respiration, with glucose as the primary reactant, is shown below.

$$2C_6H_{12}O_6 + 12O_2 \rightarrow 12CO_2 + 12H_2O \quad \Delta H = -5632\ kJ$$

$\Delta H = -2816\ kJ/mol$

The theoretical amount of energy produced through cellular respiration from the O_2 retained by the body in a normal breath would be:

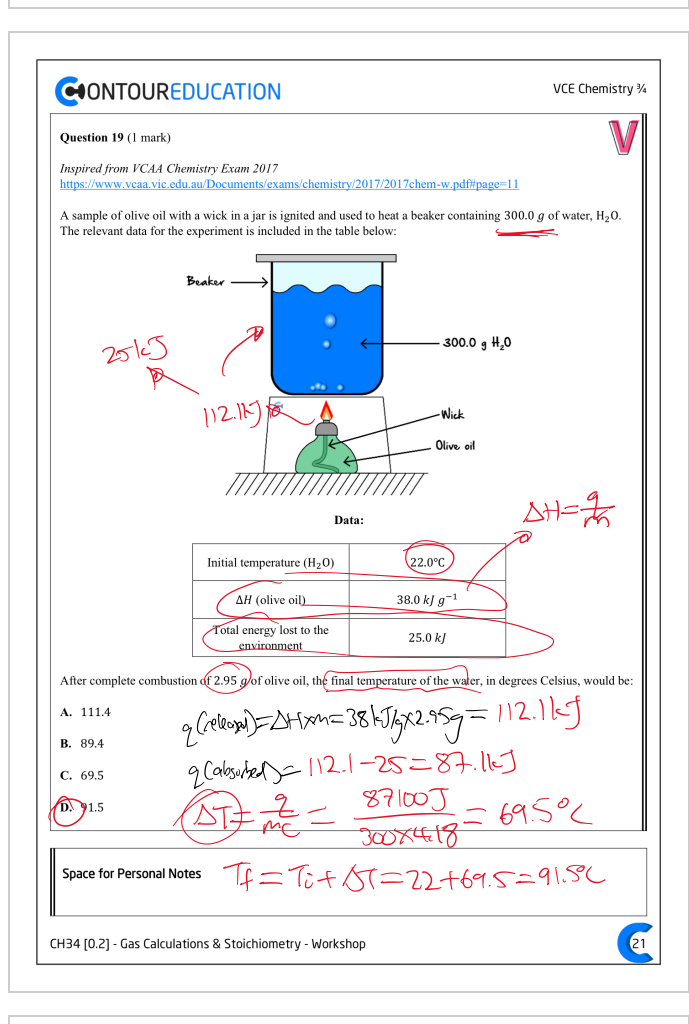
A. 4.4 kJ
B. $3.7 \times 10^{-1}\ kJ$
C. $7.4 \times 10^{-1}\ kJ$
D. $3.7 \times 10^2\ kJ$

$n(O_2) = \frac{V}{V_m} = \frac{0.0196}{24.8} = 0.000790\ mol$

$n(C_6H_{12}O_6) = \frac{1}{6} n(O_2) = 0.000132\ mol$

$q = \Delta H \times n = 2816 \times 0.000132 = 0.371\ kJ$

Space for Personal Notes



Question 19 (1 mark)

Inspired from VCAA Chemistry Exam 2017
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2017/2017chem-w.pdf#page=11

A sample of olive oil with a wick in a jar is ignited and used to heat a beaker containing 300.0 g of water, H_2O. The relevant data for the experiment is included in the table below:

Beaker
300.0 g H2O
Wick
Olive oil
25 kJ
112.1 kJ

$\Delta H = \frac{q}{m}$

Data:

Initial temperature (H_2O)	22.0°C
ΔH (olive oil)	38.0 $kJ\ g^{-1}$
Total energy lost to the environment	25.0 kJ

After complete combustion of 2.95 g of olive oil, the final temperature of the water, in degrees Celsius, would be:

A. 111.4
B. 89.4
C. 69.5
D. 91.5

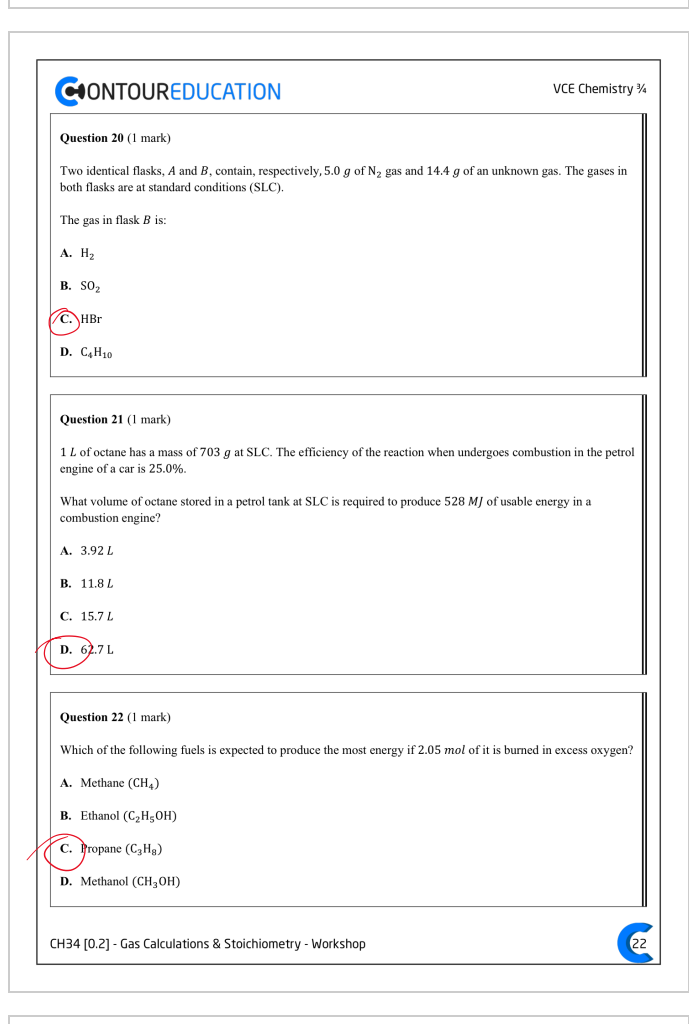
$q(released) = \Delta H \times m = 38\ kJ/g \times 2.95\ g = 112.1\ kJ$

$q(absorbed) = 112.1 - 25 = 87.1\ kJ$

$\Delta T = \frac{q}{mc} = \frac{87100\ J}{300 \times 4.18} = 69.5°C$

$T_f = T_i + \Delta T = 22 + 69.5 = 91.5°C$

Space for Personal Notes



Question 20 (1 mark)

Two identical flasks, A and B, contain, respectively, 5.0 g of N_2 gas and 14.4 g of an unknown gas. The gases in both flasks are at standard conditions (SLC).

The gas in flask B is:

A. H_2
B. SO_2
C. HBr
D. C_4H_{10}

Question 21 (1 mark)

1 L of octane has a mass of 703 g at SLC. The efficiency of the reaction when undergoes combustion in the petrol engine of a car is 25.0%.

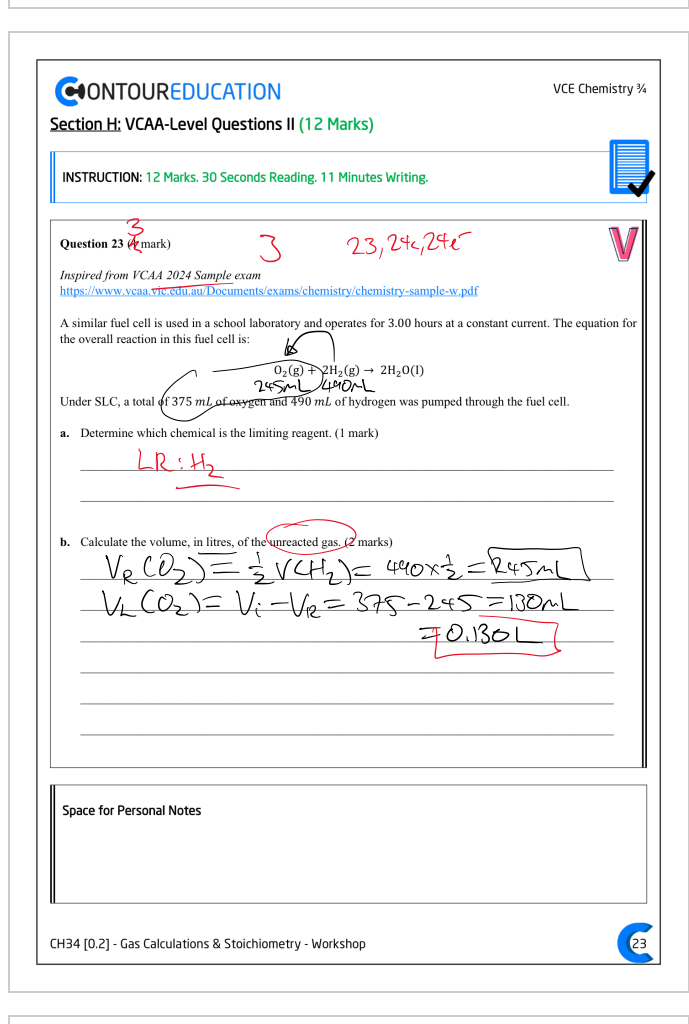
What volume of octane stored in a petrol tank at SLC is required to produce 528 MJ of usable energy in a combustion engine?

A. 3.92 L
B. 11.8 L
C. 15.7 L
D. 62.7 L

Question 22 (1 mark)

Which of the following fuels is expected to produce the most energy if 2.05 mol of it is burned in excess oxygen?

A. Methane (CH_4)
B. Ethanol (C_2H_5OH)
C. Propane (C_3H_8)
D. Methanol (CH_3OH)



Section H: VCAA-Level Questions II (12 Marks)

INSTRUCTION: 12 Marks. 30 Seconds Reading. 11 Minutes Writing.

Question 23 (~~4~~ 3 mark)   3   23, 24c, 24e

Inspired from VCAA 2024 Sample exam
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/chem-sample-w.pdf

A similar fuel cell is used in a school laboratory and operates for 3.00 hours at a constant current. The equation for the overall reaction in this fuel cell is:

$$O_2(g) + 2H_2(g) \rightarrow 2H_2O(l)$$

245 mL   490 mL

Under SLC, a total of 375 mL of oxygen and 490 mL of hydrogen was pumped through the fuel cell.

a. Determine which chemical is the limiting reagent. (1 mark)

LR: H_2

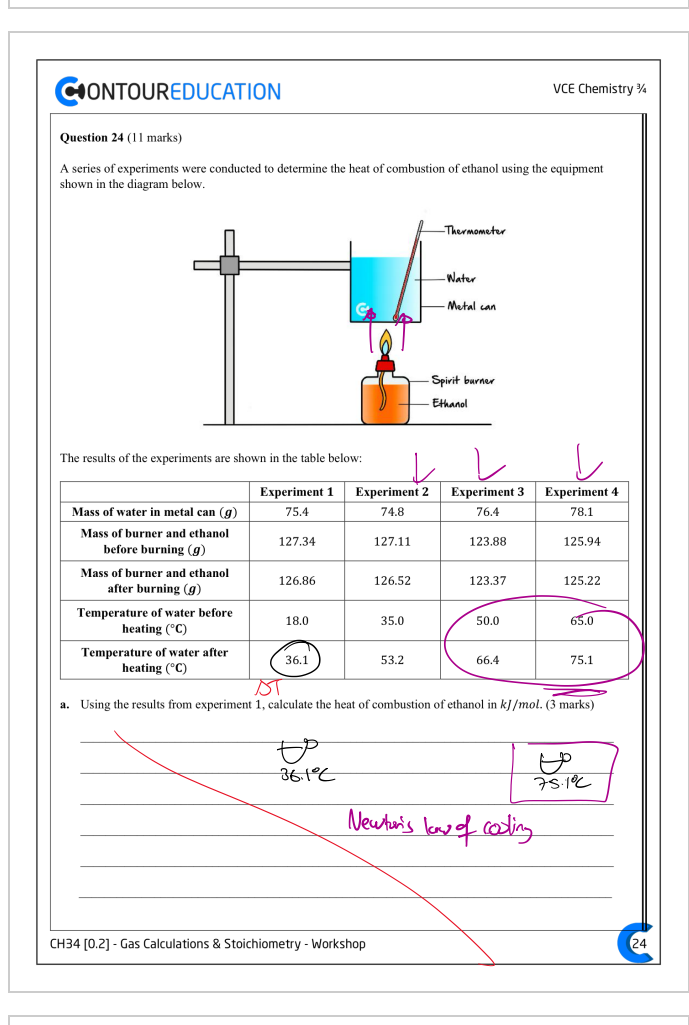
b. Calculate the volume, in litres, of the unreacted gas. (2 marks)

$V_R(O_2) = \frac{1}{2} V(H_2) = 490 \times \frac{1}{2} = 245\ mL$

$V_L(O_2) = V_i - V_R = 375 - 245 = 130\ mL$

$= \boxed{0.130\ L}$

Space for Personal Notes



Question 24 (11 marks)

A series of experiments were conducted to determine the heat of combustion of ethanol using the equipment shown in the diagram below.

Thermometer
Water
Metal can
Spirit burner
Ethanol

The results of the experiments are shown in the table below.

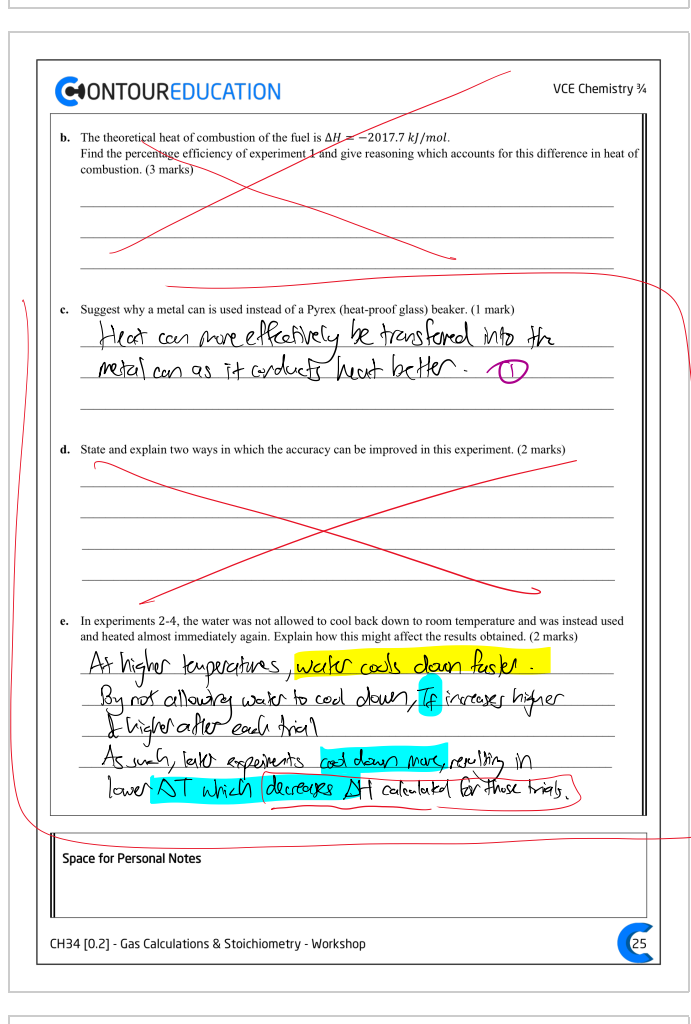
	Experiment 1	Experiment 2	Experiment 3	Experiment 4
Mass of water in metal can (g)	75.4	74.8	76.4	78.1
Mass of burner and ethanol before burning (g)	127.34	127.11	123.88	125.94
Mass of burner and ethanol after burning (g)	126.86	126.52	123.37	125.22
Temperature of water before heating (°C)	18.0	35.0	50.0	65.0
Temperature of water after heating (°C)	36.1	53.2	66.4	75.1

ΔT

a. Using the results from experiment 1, calculate the heat of combustion of ethanol in kJ/mol. (3 marks)

36.1°C   75.1°C

Newton's law of cooling



b. The theoretical heat of combustion of the fuel is $\Delta H = -2017.7\ kJ/mol$.
Find the percentage efficiency of experiment 1 and give reasoning which accounts for this difference in heat of combustion. (3 marks)

c. Suggest why a metal can is used instead of a Pyrex (heat-proof glass) beaker. (1 mark)

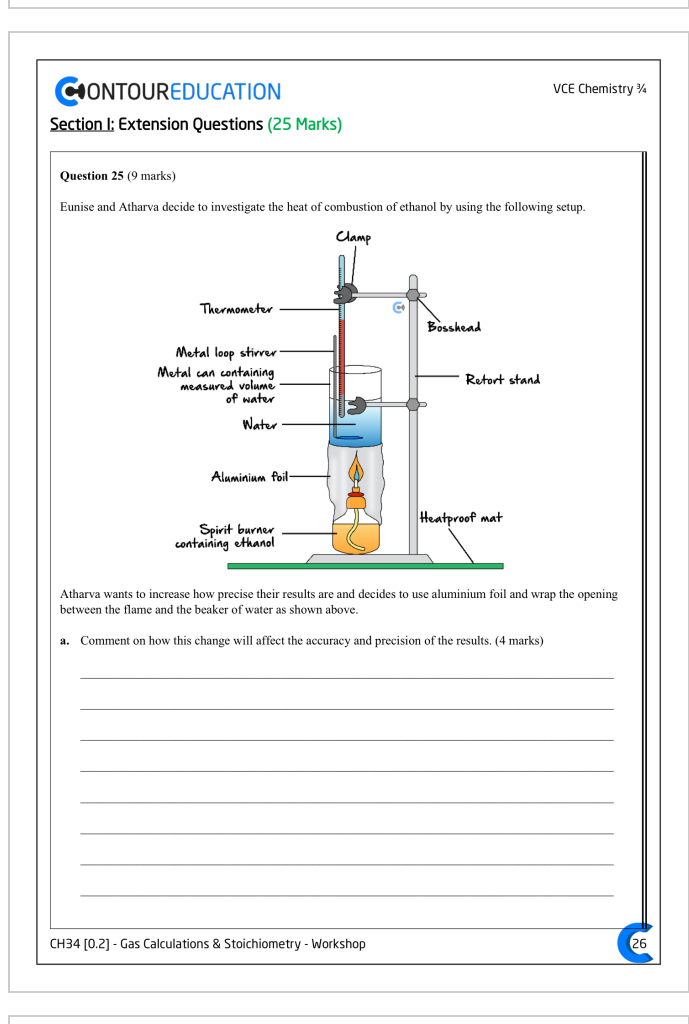
Heat can more effectively be transferred into the metal can as it conducts heat better. ①

d. State and explain two ways in which the accuracy can be improved in this experiment. (2 marks)

e. In experiments 2-4, the water was not allowed to cool back down to room temperature and was instead used and heated almost immediately again. Explain how this might affect the results obtained. (2 marks)

At higher temperatures, water cools down faster.
By not allowing water to cool down, Ti increases higher & higher after each trial.
As such, later experiments cool down more, resulting in lower ΔT which decreases ΔH calculated for these trials.

Space for Personal Notes



Section I: Extension Questions (25 Marks)

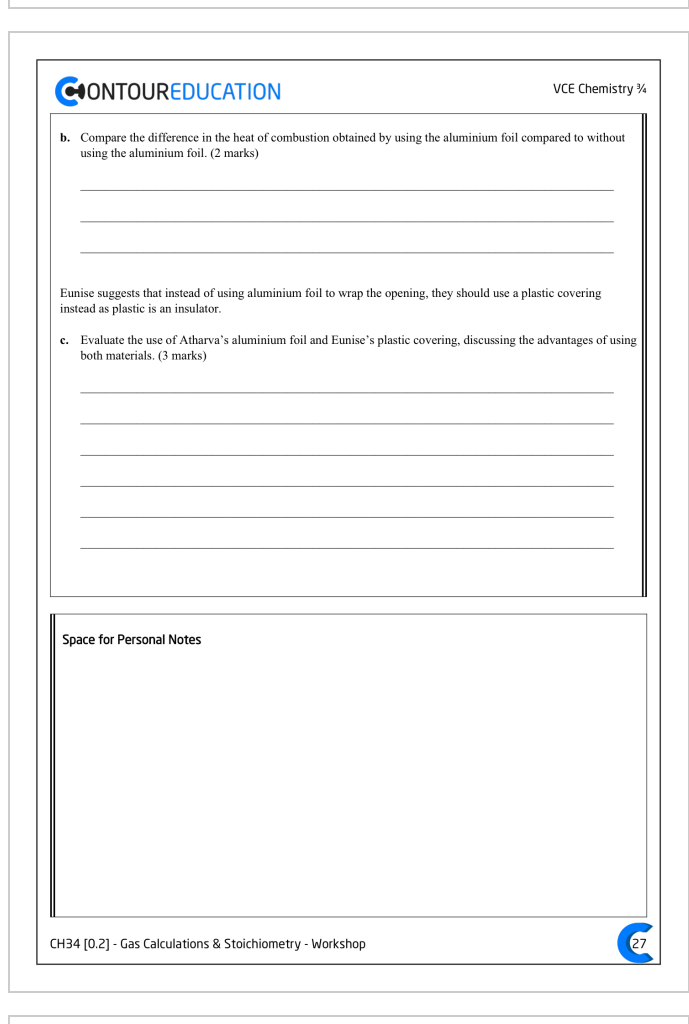
Question 25 (9 marks)

Eunise and Atharva decide to investigate the heat of combustion of ethanol by using the following setup.

Clamp
Thermometer
Bosshead
Metal loop stirrer
Metal can containing measured volume of water
Retort stand
Water
Aluminium foil
Heatproof mat
Spirit burner containing ethanol

Atharva wants to increase how precise their results are and decides to use aluminium foil and wrap the opening between the flame and the beaker of water as shown above.

a. Comment on how this change will affect the accuracy and precision of the results. (4 marks)

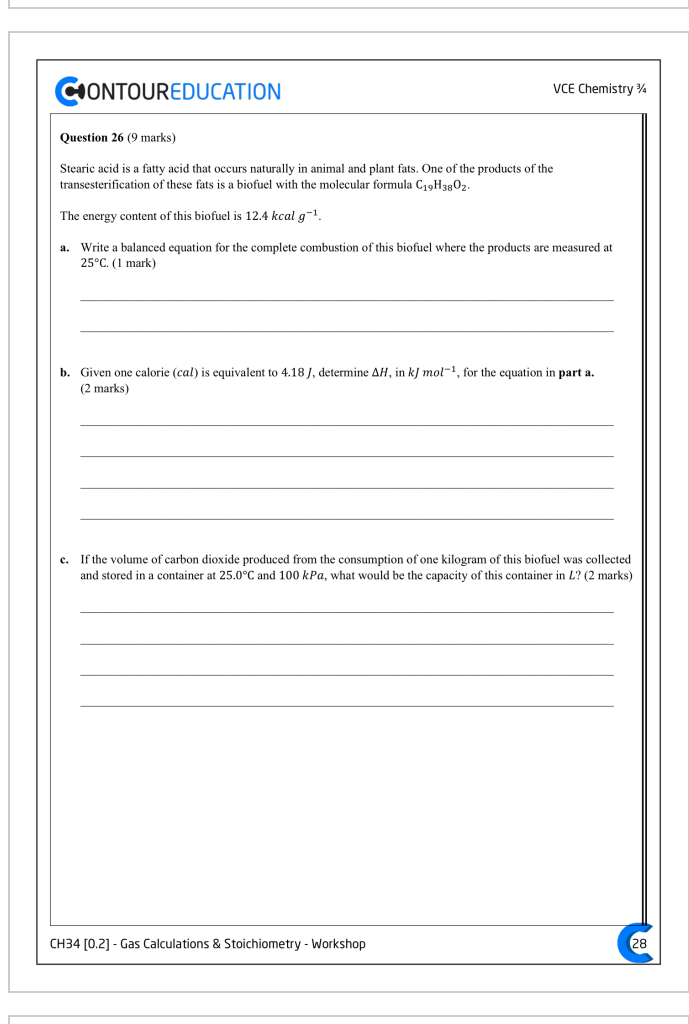


b. Compare the difference in the heat of combustion obtained by using the aluminium foil compared to without using the aluminium foil. (2 marks)

Eunise suggests that instead of using aluminium foil to wrap the opening, they should use a plastic covering instead as plastic is an insulator.

c. Evaluate the use of Atharva's aluminium foil and Eunise's plastic covering, discussing the advantages of using both materials. (3 marks)

Space for Personal Notes



Question 26 (9 marks)

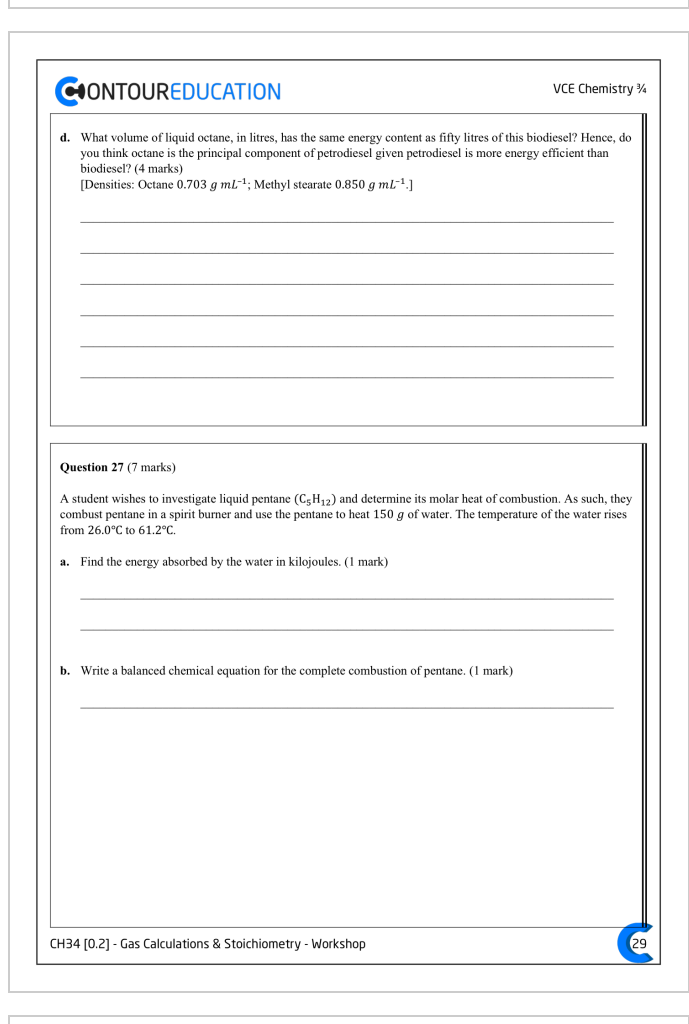
Stearic acid is a fatty acid that occurs naturally in animal and plant fats. One of the products of the transesterification of these fats is a biofuel with the molecular formula $C_{19}H_{38}O_2$.

The energy content of this biofuel is 12.4 $kcal\ g^{-1}$.

a. Write a balanced equation for the complete combustion of this biofuel where the products are measured at 25°C. (1 mark)

b. Given one calorie (cal) is equivalent to 4.18 J, determine ΔH, in $kJ\ mol^{-1}$, for the equation in **part a.** (2 marks)

c. If the volume of carbon dioxide produced from the consumption of one kilogram of this biofuel was collected and stored in a container at 25.0°C and 100 kPa, what would be the capacity of this container in L? (2 marks)



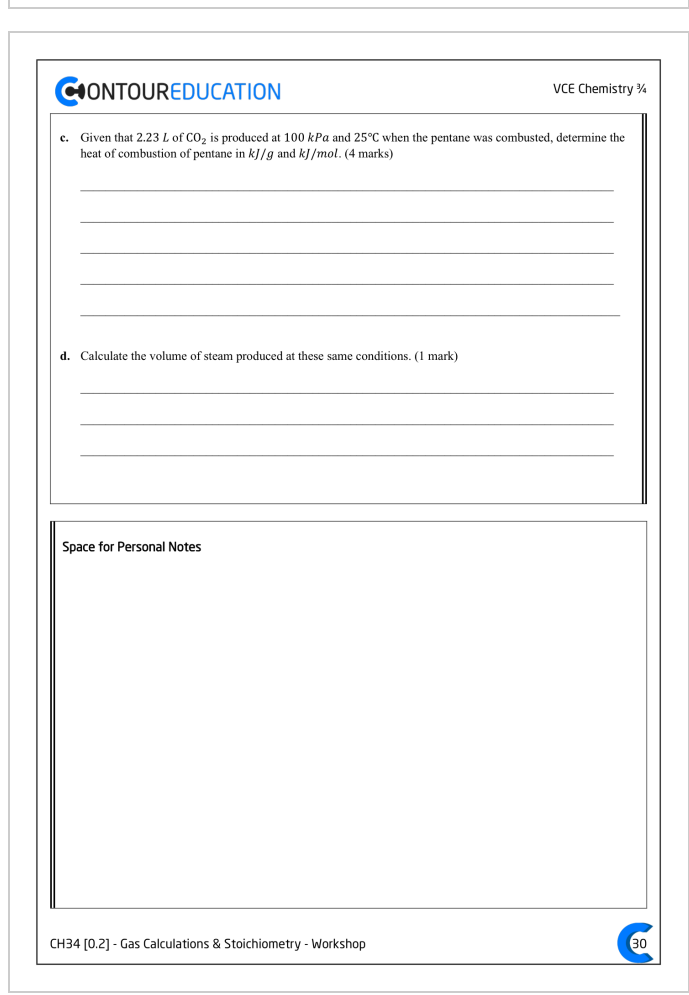
d. What volume of liquid octane, in litres, has the same energy content as fifty litres of this biodiesel? Hence, do you think octane is the principal component of petrodiesel given petrodiesel is more energy efficient than biodiesel? (4 marks)
[Densities: Octane 0.703 $g\ mL^{-1}$; Methyl stearate 0.850 $g\ mL^{-1}$.]

Question 27 (7 marks)

A student wishes to investigate liquid pentane (C_5H_{12}) and determine its molar heat of combustion. As such, they combust pentane in a spirit burner and use the pentane to heat 150 g of water. The temperature of the water rises from 26.0°C to 61.2°C.

a. Find the energy absorbed by the water in kilojoules. (1 mark)

b. Write a balanced chemical equation for the complete combustion of pentane. (1 mark)



c. Given that 2.23 L of CO_2 is produced at 100 kPa and 25°C when the pentane was combusted, determine the heat of combustion of pentane in kJ/g and kJ/mol. (4 marks)

d. Calculate the volume of steam produced at these same conditions. (1 mark)

Space for Personal Notes