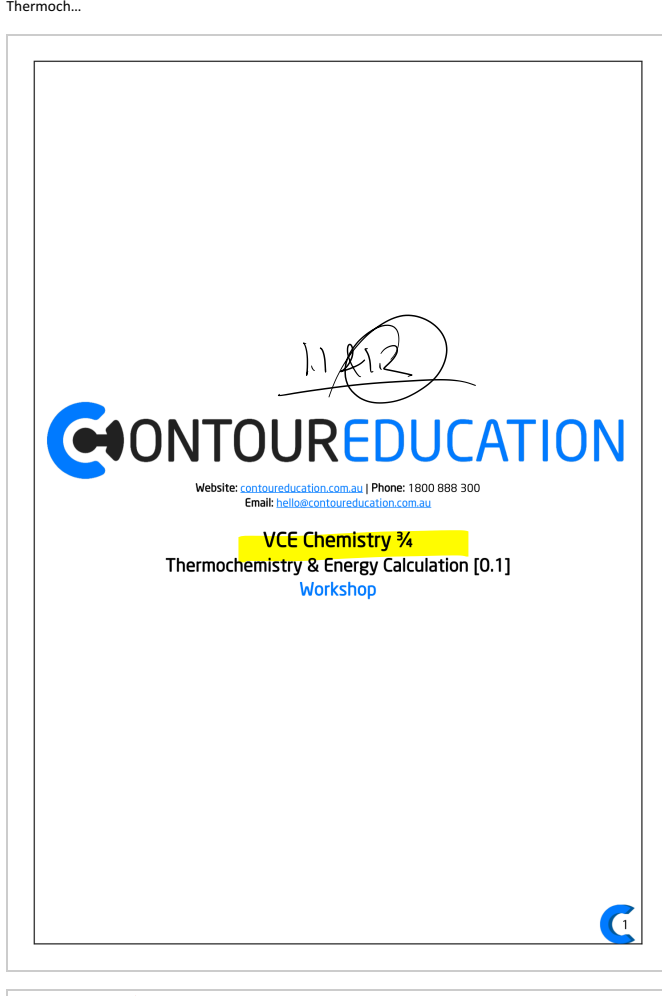
CH34 [0.1] - Thermochemistry _ Energy Calculation - Workshop

Sunday 8 December 2024 5:34 PM

CH34 [0.1] - Thermoch...



1.1 & 1.2

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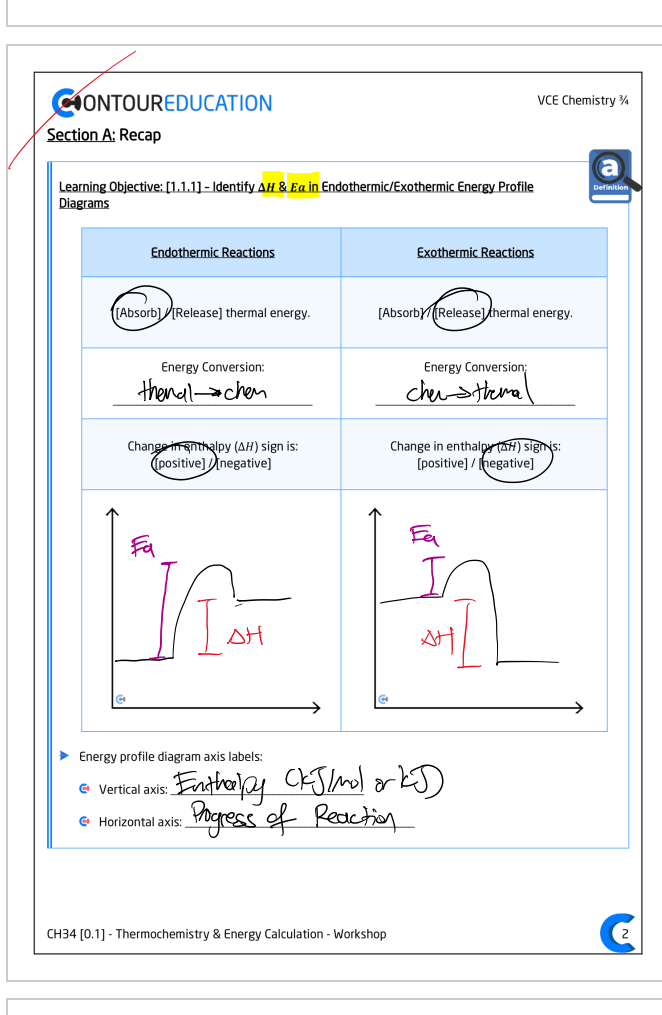
VCE Chemistry ¾
Thermochemistry & Energy Calculation [0.1]
Workshop

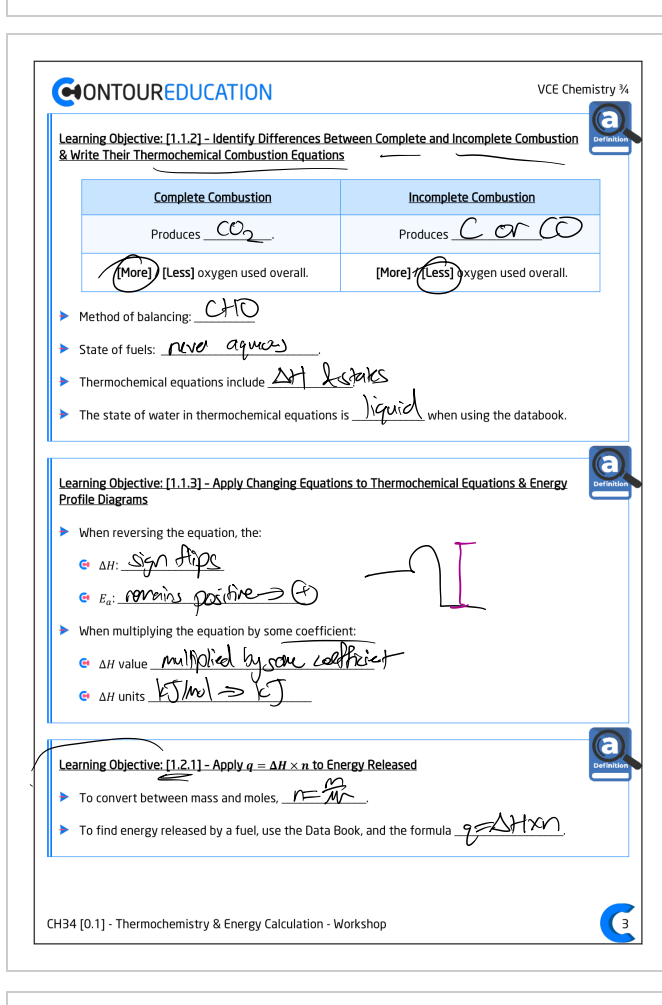


Section A: Recap

Learning Objective: [1.1.1] - Identify ΔH & Ea in Endothermic/Exothermic Energy Profile Diagrams

Endothermic Reactions	Exothermic Reactions
[✓ Absorb] / [Release] thermal energy.	[Absorb] / [✓ Release] thermal energy.
Energy Conversion: thermal → chem	Energy Conversion: chem → thermal
Change in enthalpy (ΔH) sign is: [✓ positive] / [negative]	Change in enthalpy (ΔH) sign is: [positive] / [✓ negative]

- Energy profile diagram axis labels:
  - Vertical axis: Enthalpy (kJ/mol or kJ)
  - Horizontal axis: Progress of Reaction



Learning Objective: [1.1.2] - Identify Differences Between Complete and Incomplete Combustion & Write Their Thermochemical Combustion Equations

Complete Combustion	Incomplete Combustion
Produces CO_2.	Produces C or CO
[✓ More] [Less] oxygen used overall.	[More] [✓ Less] oxygen used overall.

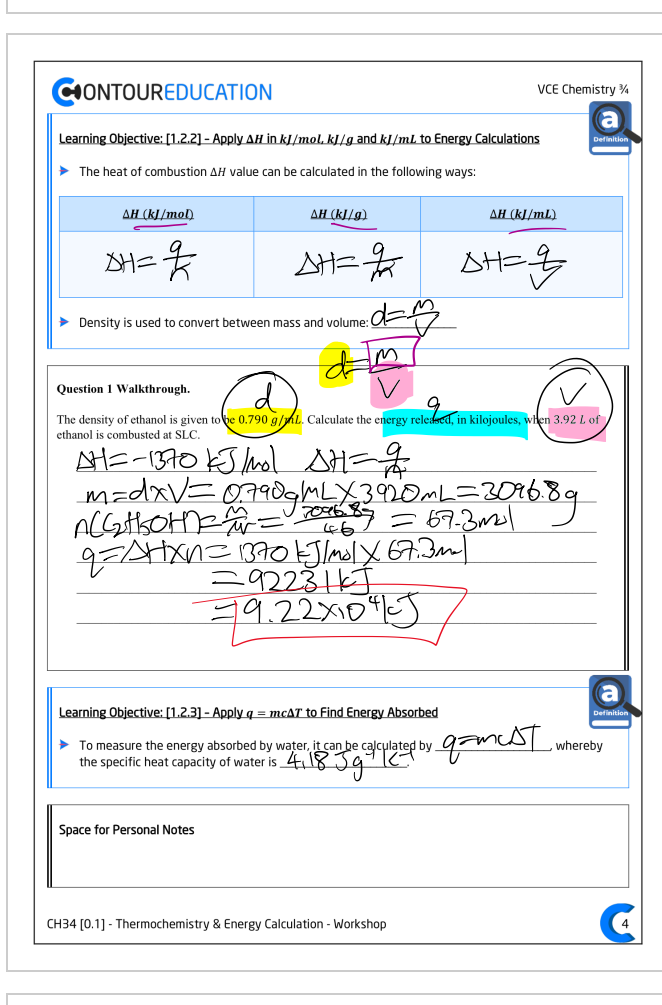
- Method of balancing: CHO
- State of fuels: never aqueous
- Thermochemical equations include ΔH & states
- The state of water in thermochemical equations is liquid when using the databook.

Learning Objective: [1.1.3] - Apply Changing Equations to Thermochemical Equations & Energy Profile Diagrams

- When reversing the equation, the:
  - ΔH: sign flips
  - E_a: remains positive → (+)
- When multiplying the equation by some coefficient:
  - ΔH value multiplied by same coefficient
  - ΔH units kJ/mol → kJ

Learning Objective: [1.2.1] - Apply $q = \Delta H \times n$ to Energy Released

- To convert between mass and moles, $n = \frac{m}{M_r}$
- To find energy released by a fuel, use the Data Book, and the formula $q = \Delta H \times n$



Learning Objective: [1.2.2] - Apply ΔH in kJ/mol, kJ/g and kJ/mL to Energy Calculations

- The heat of combustion ΔH value can be calculated in the following ways:

ΔH (kJ/mol)	ΔH (kJ/g)	ΔH (kJ/mL)
$\Delta H = \frac{q}{n}$	$\Delta H = \frac{q}{m}$	$\Delta H = \frac{q}{V}$

- Density is used to convert between mass and volume: $d = \frac{m}{V}$

Question 1 Walkthrough.

The density of ethanol is given to be 0.790 g/mL. Calculate the energy released, in kilojoules, when 3.92 L of ethanol is combusted at SLC.

$\Delta H = -1370\ kJ/mol \quad \Delta H = \frac{q}{n}$

$m = d \times V = 0.790 g/mL \times 3920 mL = 3096.8 g$

$n(C_2H_5OH) = \frac{m}{M_r} = \frac{3096.8}{46} = 67.3 mol$

$q = \Delta H \times n = 1370 kJ/mol \times 67.3 mol$

$= 92231 kJ$

$= \boxed{9.22 \times 10^4 kJ}$

Learning Objective: [1.2.3] - Apply $q = mc\Delta T$ to Find Energy Absorbed

- To measure the energy absorbed by water, it can be calculated by $q = mc\Delta T$, whereby the specific heat capacity of water is $4.18\ J g^{-1} °C^{-1}$

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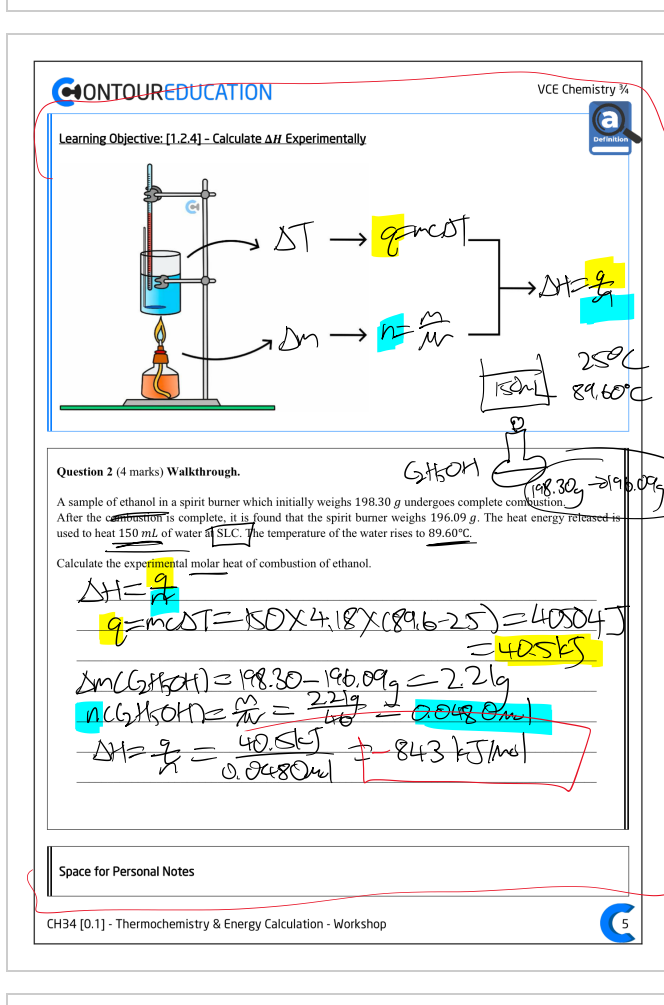

Learning Objective: [1.2.4] - Calculate ΔH Experimentally

$\Delta T \rightarrow q = mc\Delta T$

$\Delta m \rightarrow n = \frac{m}{M_r}$

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

150mL
25°C
89.60°C

Question 2 (4 marks) **Walkthrough.**

A sample of ethanol in a spirit burner which initially weighs 198.30 g undergoes complete combustion. After the combustion is complete, it is found that the spirit burner weighs 196.09 g. The heat energy released is used to heat 150 mL of water at SLC. The temperature of the water rises to 89.60°C.

Calculate the experimental molar heat of combustion of ethanol.

C_2H_5OH 198.30 − 196.09g

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

$q = mc\Delta T = 150 \times 4.18 \times (89.6 - 25) = 40504 J = 40.5 kJ$

$\Delta m(C_2H_5OH) = 198.30 - 196.09 g = 2.21 g$

$n(C_2H_5OH) = \frac{m}{M_r} = \frac{2.21 g}{46} = 0.0480 mol$

$\Delta H = \frac{q}{n} = \frac{40.5 kJ}{0.0480 mol} = \boxed{843 kJ/mol}$

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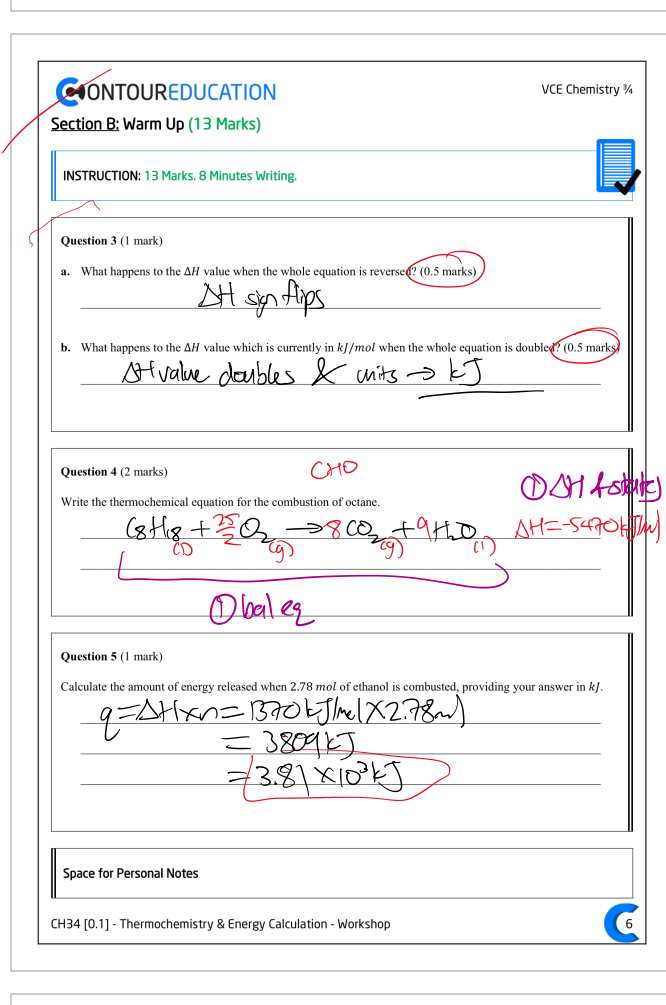

Section B: Warm Up (13 Marks)

INSTRUCTION: 13 Marks. 8 Minutes Writing.

Question 3 (1 mark)

a. What happens to the ΔH value when the whole equation is reversed? (0.5 marks)

ΔH sign flips

b. What happens to the ΔH value which is currently in kJ/mol when the whole equation is doubled? (0.5 marks)

ΔH value doubles & units → kJ

Question 4 (2 marks)

Write the thermochemical equation for the combustion of octane.

CHO ① ΔH & states

$C_8H_{18}(l) + \frac{25}{2}O_2(g) \rightarrow 8CO_2(g) + 9H_2O(l) \quad \Delta H = -5470 kJ/mol$

① bal eq

Question 5 (1 mark)

Calculate the amount of energy released when 2.78 mol of ethanol is combusted, providing your answer in kJ.

$q = \Delta H \times n = 1370 kJ/mol \times 2.78 mol$

$= 3809 kJ$

$= \boxed{3.81 \times 10^3 kJ}$

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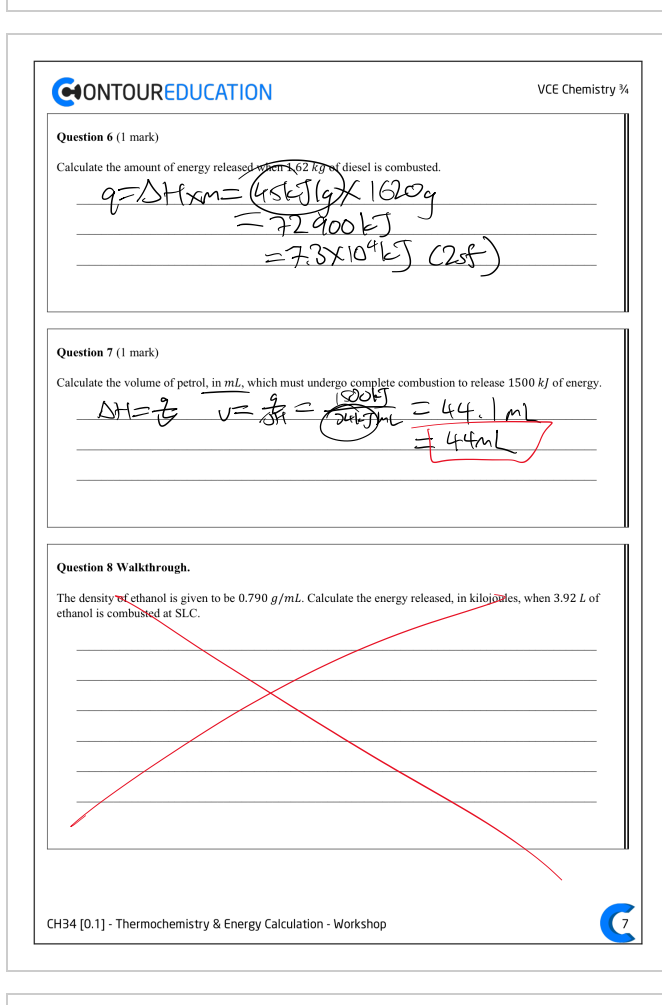


Question 6 (1 mark)

Calculate the amount of energy released when 1.62 kg of diesel is combusted.

$q = \Delta H \times m = 45 kJ/g \times 1620 g$

$= 72900 kJ$

$= 7.3 \times 10^4 kJ$ (2sf)

Question 7 (1 mark)

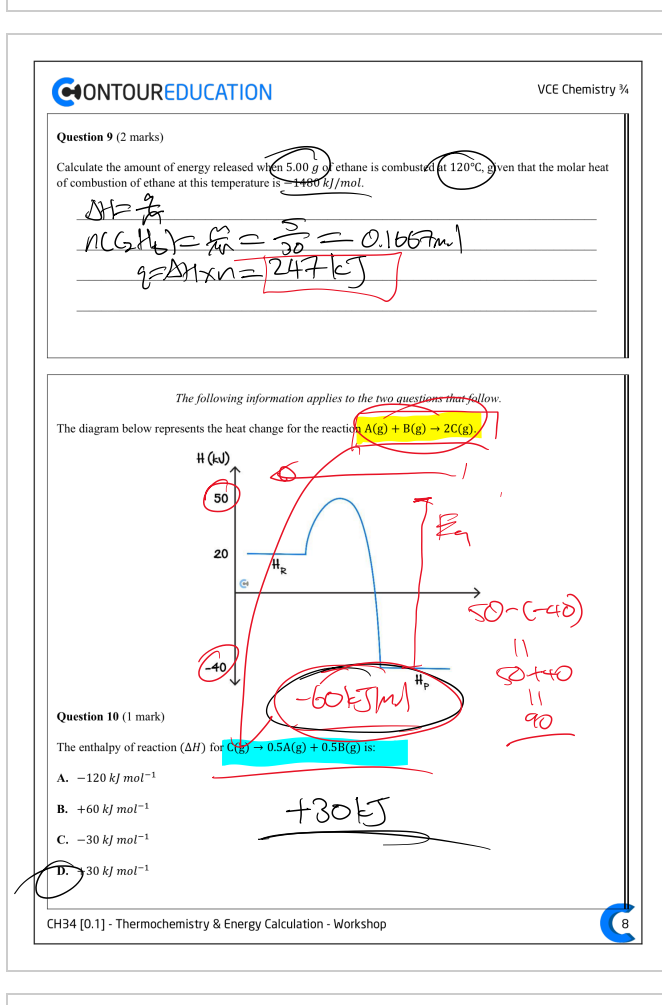
Calculate the volume of petrol, in mL, which must undergo complete combustion to release 1500 kJ of energy.

$\Delta H = \frac{q}{V} \quad V = \frac{q}{\Delta H} = \frac{1500 kJ}{34 kJ/mL} = 44.1 mL$

$= \boxed{44 mL}$

Question 8 Walkthrough.

~~The density of ethanol is given to be 0.790 g/mL. Calculate the energy released, in kilojoules, when 3.92 L of ethanol is combusted at SLC.~~



Question 9 (2 marks)

Calculate the amount of energy released when 5.00 g of ethane is combusted at 120°C, given that the molar heat of combustion of ethane at this temperature is ~~1480~~ kJ/mol.

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

$n(C_2H_6) = \frac{m}{M_r} = \frac{5}{30} = 0.1667 mol$

$q = \Delta H \times n = \boxed{247 kJ}$

The following information applies to the two questions that follow.

The diagram below represents the heat change for the reaction $A(g) + B(g) \rightarrow 2C(g)$.

Question 10 (1 mark)

The enthalpy of reaction (ΔH) for $C(g) \rightarrow 0.5A(g) + 0.5B(g)$ is:

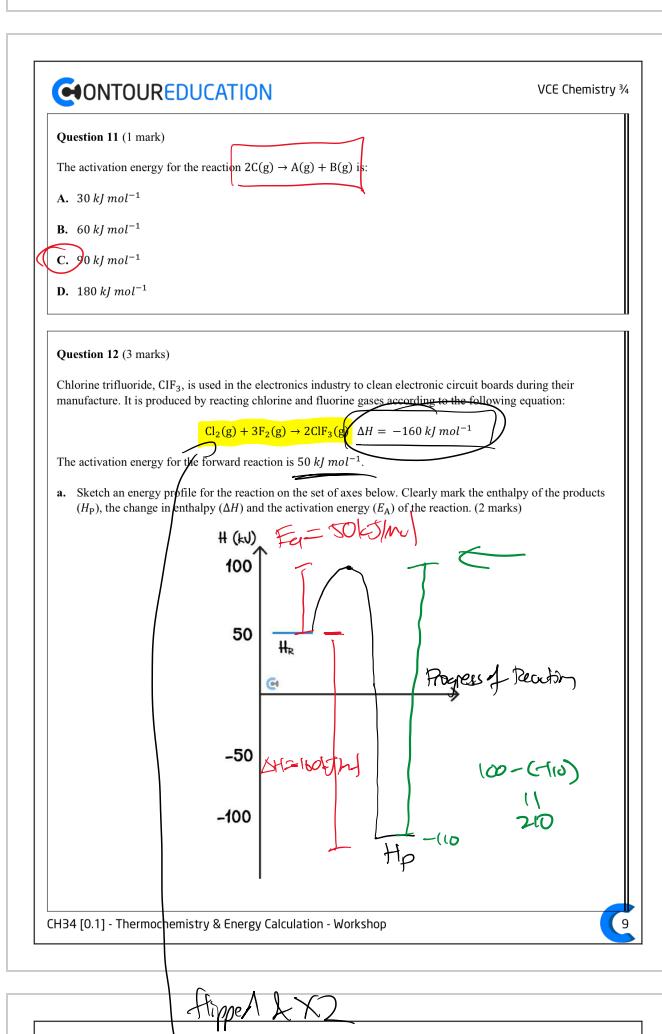
A. $-120\ kJ\ mol^{-1}$

B. $+60\ kJ\ mol^{-1}$

C. $-30\ kJ\ mol^{-1}$

[✓ D.] $+30\ kJ\ mol^{-1}$

+30kJ



Question 11 (1 mark)

The activation energy for the reaction $2C(g) \rightarrow A(g) + B(g)$ is:

A. 30 $kJ\ mol^{-1}$

B. 60 $kJ\ mol^{-1}$

[✓ C.] 90 $kJ\ mol^{-1}$

D. 180 $kJ\ mol^{-1}$

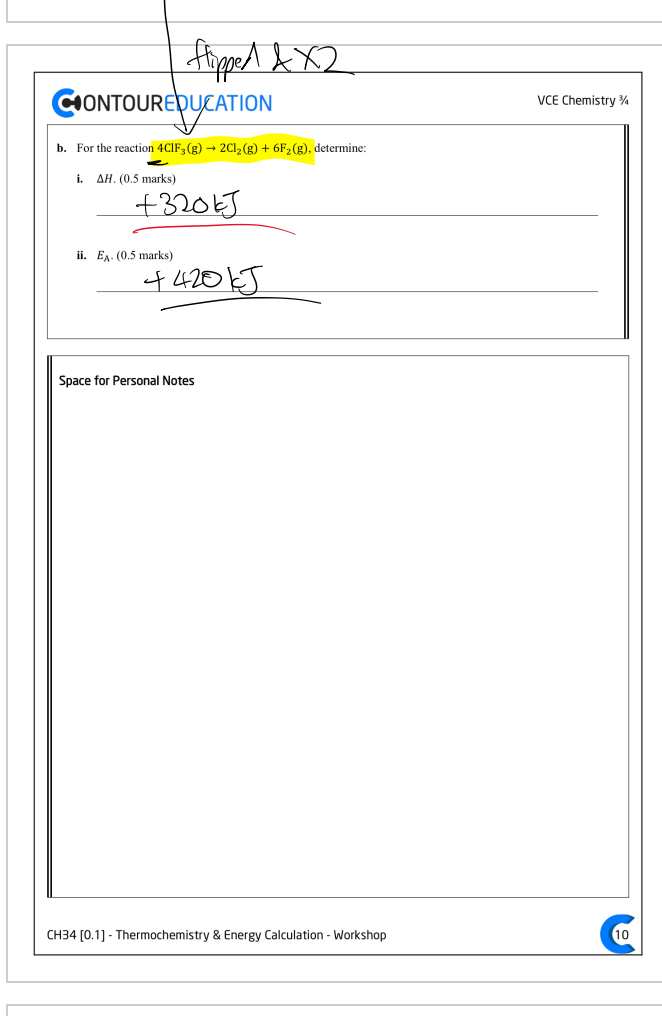
Question 12 (3 marks)

Chlorine trifluoride, ClF_3, is used in the electronics industry to clean electronic circuit boards during their manufacture. It is produced by reacting chlorine and fluorine gases according to the following equation:

$Cl_2(g) + 3F_2(g) \rightarrow 2ClF_3(g) \quad \Delta H = -160\ kJ\ mol^{-1}$

The activation energy for the forward reaction is 50 $kJ\ mol^{-1}$.

a. Sketch an energy profile for the reaction on the set of axes below. Clearly mark the enthalpy of the products (H_P), the change in enthalpy (ΔH) and the activation energy (E_a) of the reaction. (2 marks)



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b. For the reaction $4ClF_3(g) \rightarrow 2Cl_2(g) + 6F_2(g)$, determine:

i. ΔH. (0.5 marks)

+320kJ

ii. E_a. (0.5 marks)

+420kJ

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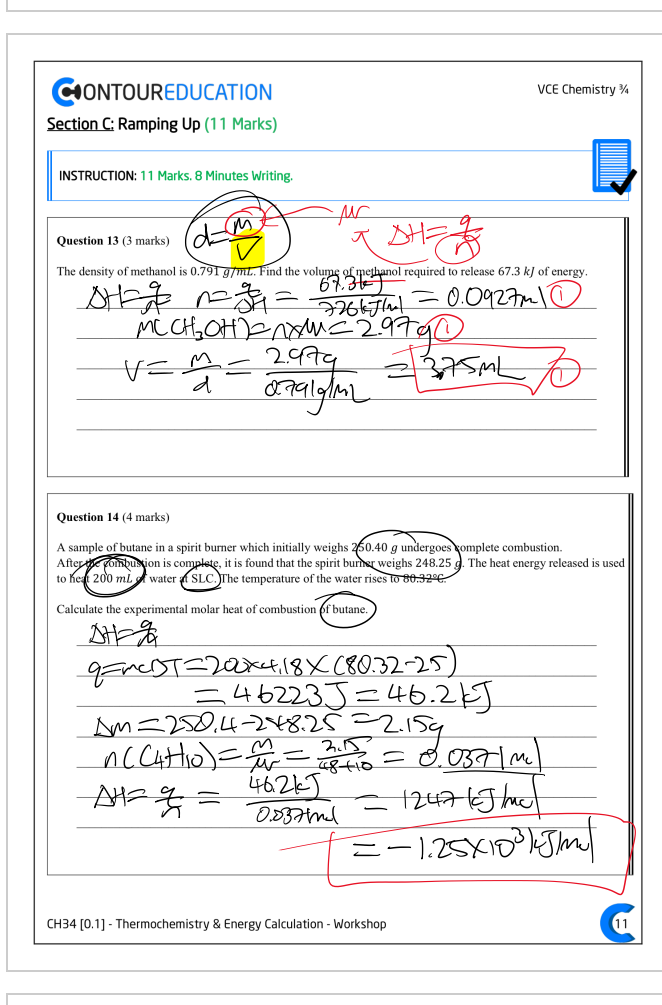


Section C: Ramping Up (11 Marks)

INSTRUCTION: 11 Marks. 8 Minutes Writing.

Question 13 (3 marks)

The density of methanol is 0.791 g/mL. Find the volume of methanol required to release 67.3 kJ of energy.

$d = \frac{m}{V} \quad M_r \quad q \quad \Delta H = \frac{q}{n}$

$\Delta H = \frac{q}{n} \quad n = \frac{q}{\Delta H} = \frac{67.3 kJ}{726 kJ/mol} = 0.0927 mol$ ①

$m(CH_3OH) = n \times M = 2.97 g$ ①

$V = \frac{m}{d} = \frac{2.97 g}{0.791 g/mL} = \boxed{3.75 mL}$ ①

Question 14 (4 marks)

A sample of butane in a spirit burner which initially weighs 250.40 g undergoes complete combustion. After the combustion is complete, it is found that the spirit burner weighs 248.25 g. The heat energy released is used to heat 200 mL of water at SLC. The temperature of the water rises to 80.32°C.

Calculate the experimental molar heat of combustion of butane.

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

$q = mc\Delta T = 200 \times 4.18 \times (80.32 - 25)$

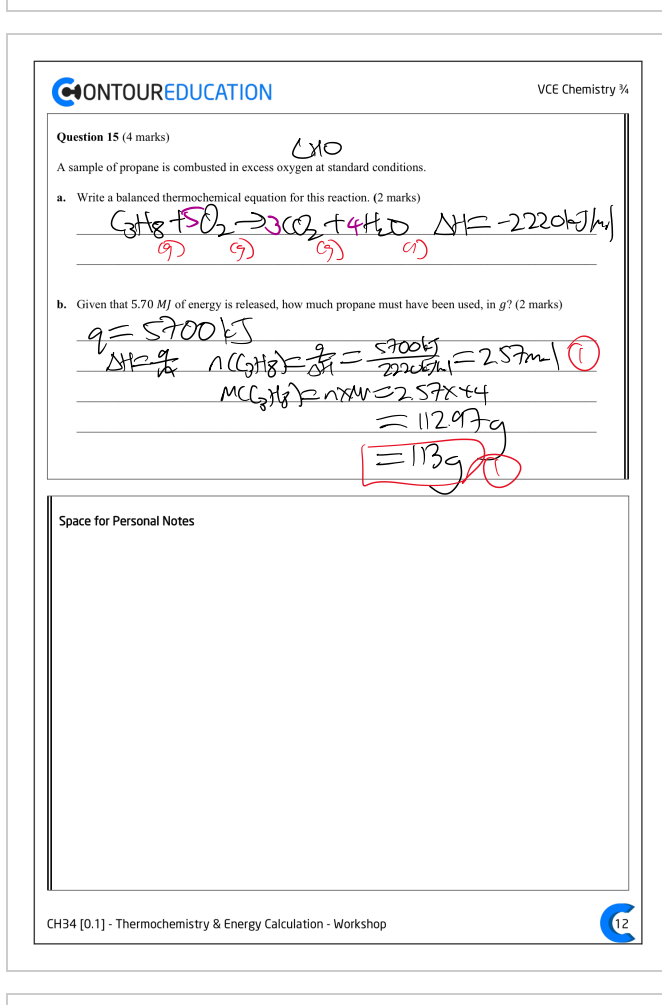
$= 46223 J = 46.2 kJ$

$\Delta m = 250.4 - 248.25 = 2.15 g$

$n(C_4H_{10}) = \frac{m}{M_r} = \frac{2.15}{58} = 0.0371 mol$

$\Delta H = \frac{q}{n} = \frac{46.2 kJ}{0.0371 mol} = 1247 kJ/mol$

$= \boxed{-1.25 \times 10^3 kJ/mol}$



Question 15 (4 marks)

A sample of propane is combusted in excess oxygen at standard conditions.

CHO

a. Write a balanced thermochemical equation for this reaction. (2 marks)

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

b. Given that 5.70 MJ of energy is released, how much propane must have been used, in g? (2 marks)

$q = 5700 kJ$

$\Delta H = \frac{q}{n} \quad n(C_3H_8) = \frac{q}{\Delta H} = \frac{5700 kJ}{2220 kJ/mol} = 2.57 mol$ ①

$m(C_3H_8) = n \times M = 2.57 \times 44$

$= 112.97 g$

$= \boxed{113 g}$ ①

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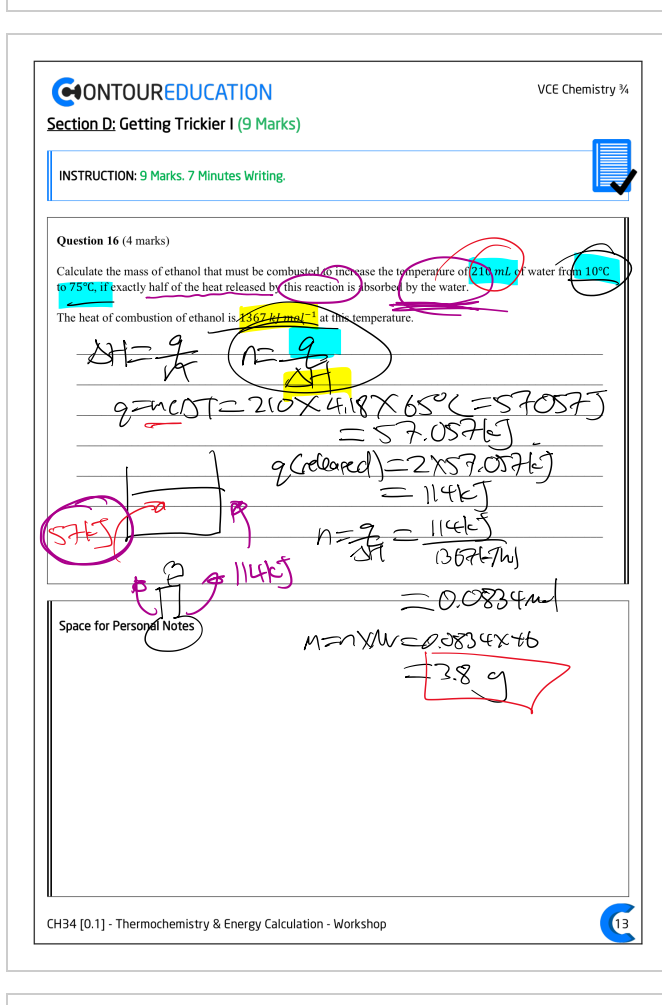

Section D: Getting Trickier I (9 Marks)

INSTRUCTION: 9 Marks. 7 Minutes Writing.

Question 16 (4 marks)

Calculate the mass of ethanol that must be combusted to increase the temperature of 210 mL of water from 10°C to 75°C, if exactly half of the heat released by this reaction is absorbed by the water.

The heat of combustion of ethanol is 1367 $kJ\ mol^{-1}$ at this temperature.

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

$q = mc\Delta T = 210 \times 4.18 \times 65°C = 57057 J$

$= 57.057 kJ$

$q(released) = 2 \times 57.057 kJ$

$= 114 kJ$

$n = \frac{q}{\Delta H} = \frac{114 kJ}{1367 kJ/mol}$

$= 0.0834 mol$

$m = n \times M = 0.0834 \times 46$

$= \boxed{3.8 g}$

57kJ 114kJ

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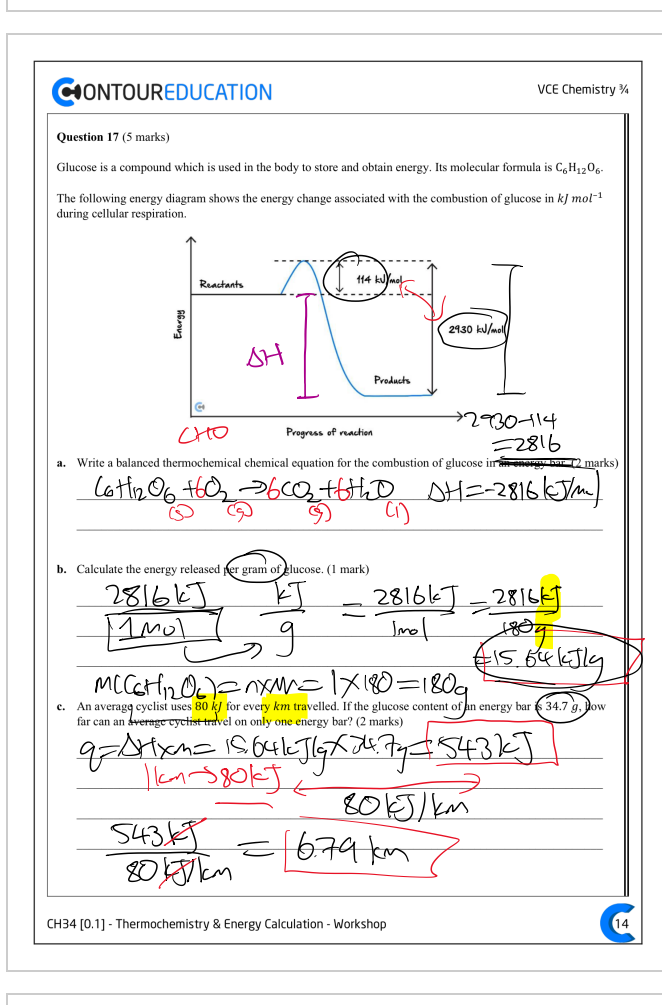


Question 17 (5 marks)

Glucose is a compound which is used in the body to store and obtain energy. Its molecular formula is $C_6H_{12}O_6$.

The following energy diagram shows the energy change associated with the combustion of glucose in $kJ\ mol^{-1}$ during cellular respiration.

Reactants
114 kJ/mol
2930 kJ/mol
Products
Energy
Progress of reaction
ΔH
2930 − 114
= 2816

CHO

a. Write a balanced thermochemical chemical equation for the combustion of glucose in [illegible] (2 marks)

$C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l) \quad \Delta H = -2816 kJ/mol$

b. Calculate the energy released per gram of glucose. (1 mark)

$\frac{2816 kJ}{1 mol} \quad \frac{kJ}{g} \quad = \frac{2816 kJ}{1 mol} = \frac{2816 kJ}{180 g} = \boxed{15.64 kJ/g}$

$M(C_6H_{12}O_6) = n \times M = 1 \times 180 = 180 g$

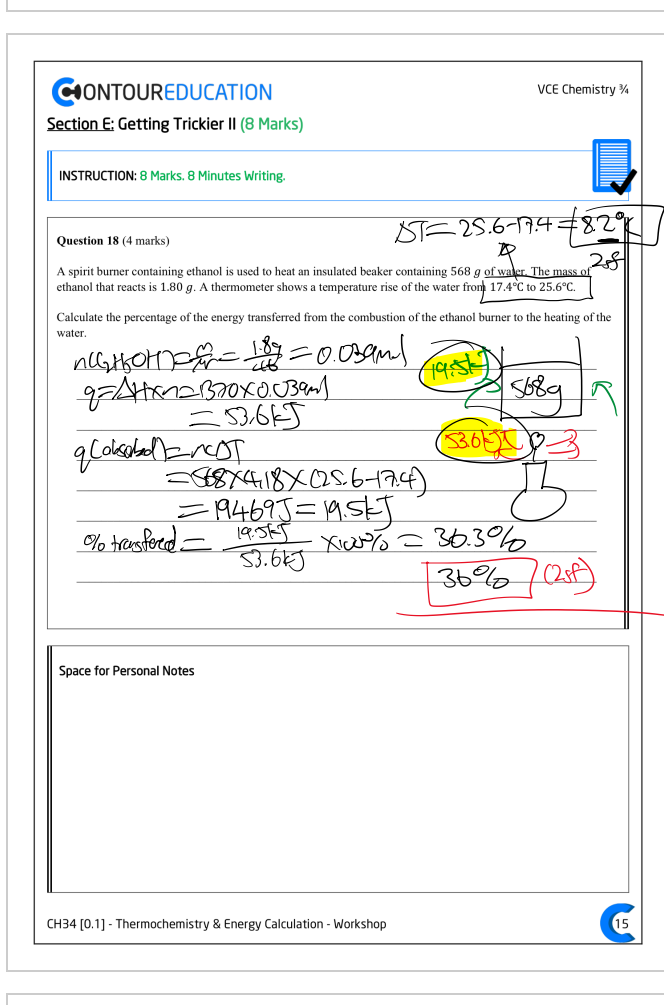
c. An average cyclist uses 80 kJ for every km travelled. If the glucose content of an energy bar is 34.7 g, how far can an average cyclist travel on only one energy bar? (2 marks)

$q = \Delta H \times m = 15.64 kJ/g \times 34.7 g = 543 kJ$

1km → 80kJ

80kJ/km

$\frac{543 kJ}{80 kJ/km} = \boxed{6.79 km}$



Section E: Getting Trickier II (8 Marks)

INSTRUCTION: 8 Marks. 8 Minutes Writing.

Question 18 (4 marks)

A spirit burner containing ethanol is used to heat an insulated beaker containing 568 g of water. The mass of ethanol that reacts is 1.80 g. A thermometer shows a temperature rise of the water from 17.4°C to 25.6°C.

Calculate the percentage of the energy transferred from the combustion of the ethanol burner to the heating of the water.

$\Delta T = 25.6 - 17.4 = 8.2°C$

$n(C_2H_5OH) = \frac{m}{M_r} = \frac{1.8}{46} = 0.039 mol$

$q = \Delta H \times n = 1370 \times 0.039 mol$

$= 53.6 kJ$

$q(absorbed) = mc\Delta T$

$= 568 \times 4.18 \times (25.6 - 17.4)$

$= 19469 J = 19.5 kJ$

$\% \text{ transferred} = \frac{19.5 kJ}{53.6 kJ} \times 100\% = 36.3\%$

$\boxed{36\%}$ (2sf)

19.5kJ 53.6kJ 568g

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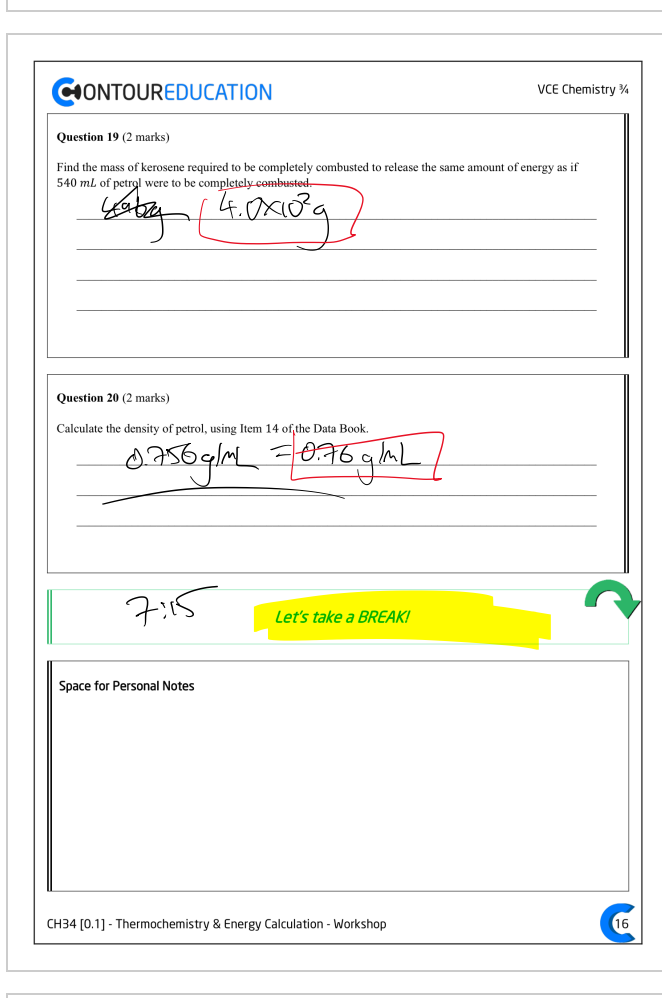

Question 19 (2 marks)

Find the mass of kerosene required to be completely combusted to release the same amount of energy as if 540 mL of petrol were to be completely combusted.

$\boxed{4.0 \times 10^2 g}$

Question 20 (2 marks)

Calculate the density of petrol, using Item 14 of the Data Book.

0.756 g/mL = $\boxed{0.76 g/mL}$

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Let's take a BREAK!

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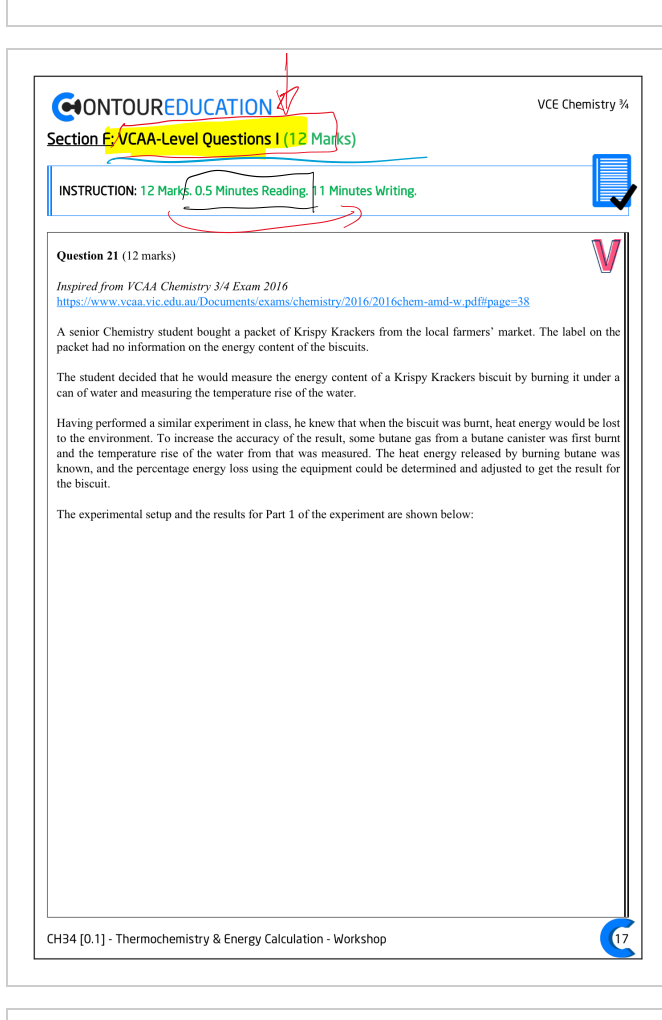


Section F: VCAA-Level Questions I (12 Marks)

INSTRUCTION: 12 Marks. 0.5 Minutes Reading. 11 Minutes Writing.

Question 21 (12 marks)

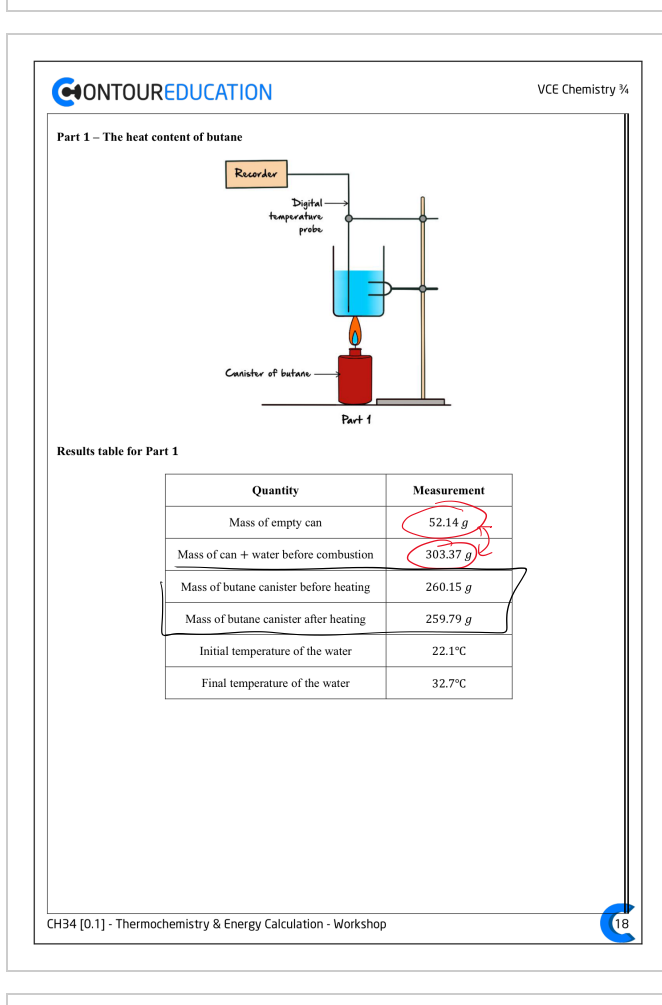
Inspired from VCAA Chemistry 3/4 Exam 2016
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2016/2016chem-amd-w.pdf#page=38

A senior Chemistry student bought a packet of Krispy Krackers from the local farmers' market. The label on the packet had no information on the energy content of the biscuits.

The student decided that he would measure the energy content of a Krispy Krackers biscuit by burning it under a can of water and measuring the temperature rise of the water.

Having performed a similar experiment in class, he knew that when the biscuit was burnt, heat energy would be lost to the environment. To increase the accuracy of the result, some butane gas from a butane canister was first burnt and the temperature rise of the water from that was measured. The heat energy released by burning butane was known, and the percentage energy loss using the equipment could be determined and adjusted to get the result for the biscuit.

The experimental setup and the results for Part 1 of the experiment are shown below:

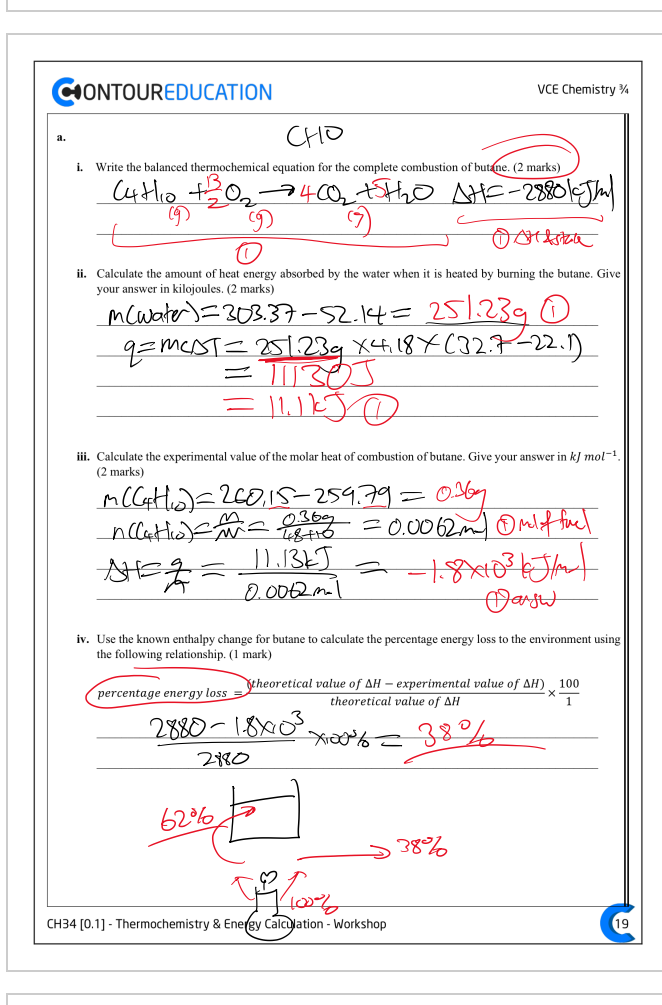


Part 1 – The heat content of butane

Recorder
Digital temperature probe
Canister of butane
Part 1

Results table for Part 1

Quantity	Measurement
Mass of empty can	52.14 g
Mass of can + water before combustion	303.37 g
Mass of butane canister before heating	260.15 g
Mass of butane canister after heating	259.79 g
Initial temperature of the water	22.1°C
Final temperature of the water	32.7°C



a.

i. Write the balanced thermochemical equation for the complete combustion of butane. (2 marks)

CHO

$C_4H_{10}(g) + \frac{13}{2}O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l) \quad \Delta H = -2880 kJ/mol$

① ΔH & states ①

ii. Calculate the amount of heat energy absorbed by the water when it is heated by burning the butane. Give your answer in kilojoules. (2 marks)

$m(water) = 303.37 - 52.14 = 251.23 g$ ①

$q = mc\Delta T = 251.23 g \times 4.18 \times (32.7 - 22.1)$

$= 11131 J$

$= 11.1 kJ$ ①

iii. Calculate the experimental value of the molar heat of combustion of butane. Give your answer in $kJ\ mol^{-1}$. (2 marks)

$m(C_4H_{10}) = 260.15 - 259.79 = 0.36 g$

$n(C_4H_{10}) = \frac{m}{M} = \frac{0.36 g}{58.10} = 0.0062 mol$ ① n & heat

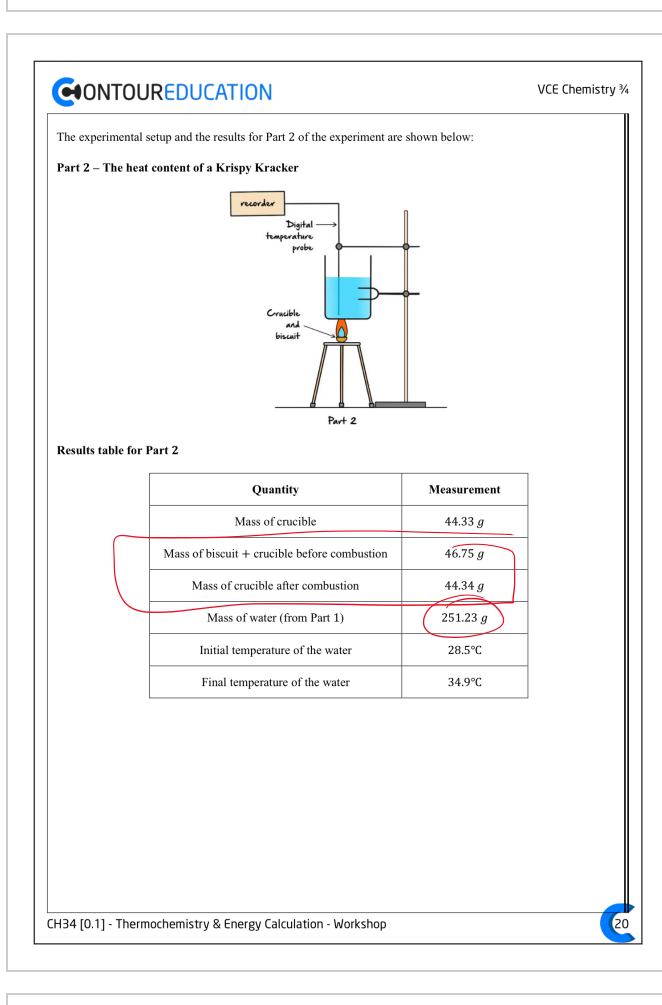
$\Delta H = \frac{q}{n} = \frac{11.13 kJ}{0.0062 mol} = -1.8 \times 10^3 kJ/mol$ ① ans

iv. Use the known enthalpy change for butane to calculate the percentage energy loss to the environment using the following relationship. (1 mark)

$$\text{percentage energy loss} = \frac{\text{theoretical value of } \Delta H - \text{experimental value of } \Delta H}{\text{theoretical value of } \Delta H} \times \frac{100}{1}$$

$\frac{2880 - 1800}{2880} \times 100\% = 38\%$

62% 38% 100%



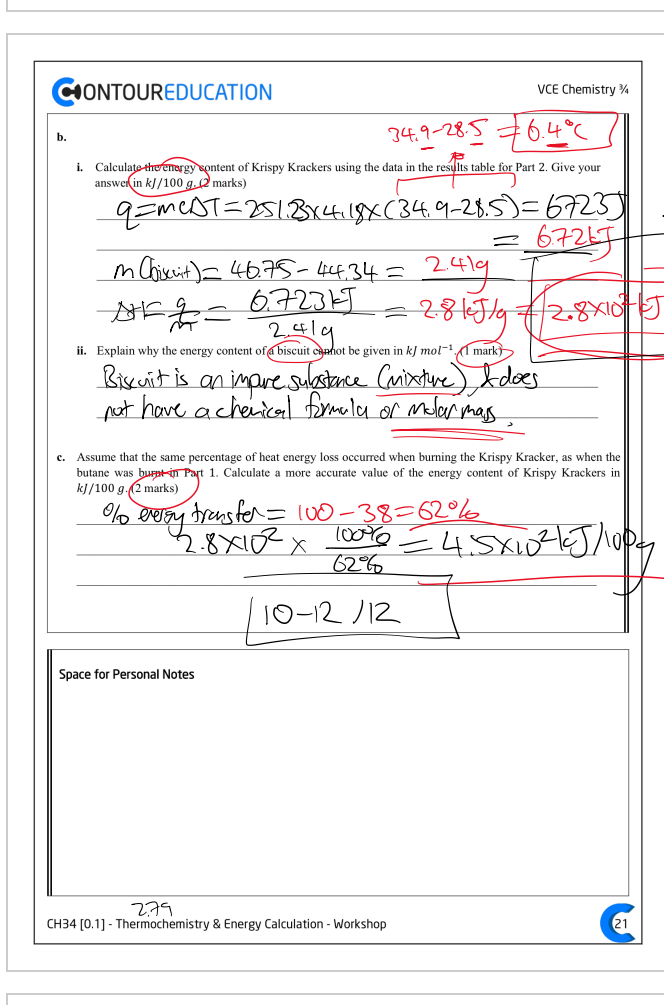
The experimental setup and the results for Part 2 of the experiment are shown below:

Part 2 – The heat content of a Krispy Kracker

Recorder
Digital temperature probe
Crucible and biscuit
Part 2

Results table for Part 2

Quantity	Measurement
Mass of crucible	44.33 g
Mass of biscuit + crucible before combustion	46.75 g
Mass of crucible after combustion	44.34 g
Mass of water (from Part 1)	251.23 g
Initial temperature of the water	28.5°C
Final temperature of the water	34.9°C



b.

$34.9 - 28.5 = 6.4°C$

i. Calculate the energy content of Krispy Krackers using the data in the results table for Part 2. Give your answer in $kJ/100\ g$. (2 marks)

$q = mc\Delta T = 251.23 \times 4.18 \times (34.9 - 28.5) = 6723 J$

$= 6.72 kJ$

$m(biscuit) = 46.75 - 44.34 = 2.41 g$

$\Delta H = \frac{q}{m} = \frac{6.72 kJ}{2.41 g} = 2.8 kJ/g = \boxed{2.8 \times 10^2 kJ/100g}$

1.3 62%

ii. Explain why the energy content of a biscuit cannot be given in $kJ\ mol^{-1}$. (1 mark)

Biscuit is an impure substance (mixture) & does not have a chemical formula or molar mass.

c. Assume that the same percentage of heat energy loss occurred when burning the Krispy Kracker, as when the butane was burnt in Part 1. Calculate a more accurate value of the energy content of Krispy Krackers in $kJ/100\ g$. (2 marks)

% energy transfer = 100 − 38 = 62%

$2.8 \times 10^2 \times \frac{100\%}{62\%} = 4.5 \times 10^2 kJ/100g$

10-12 /12

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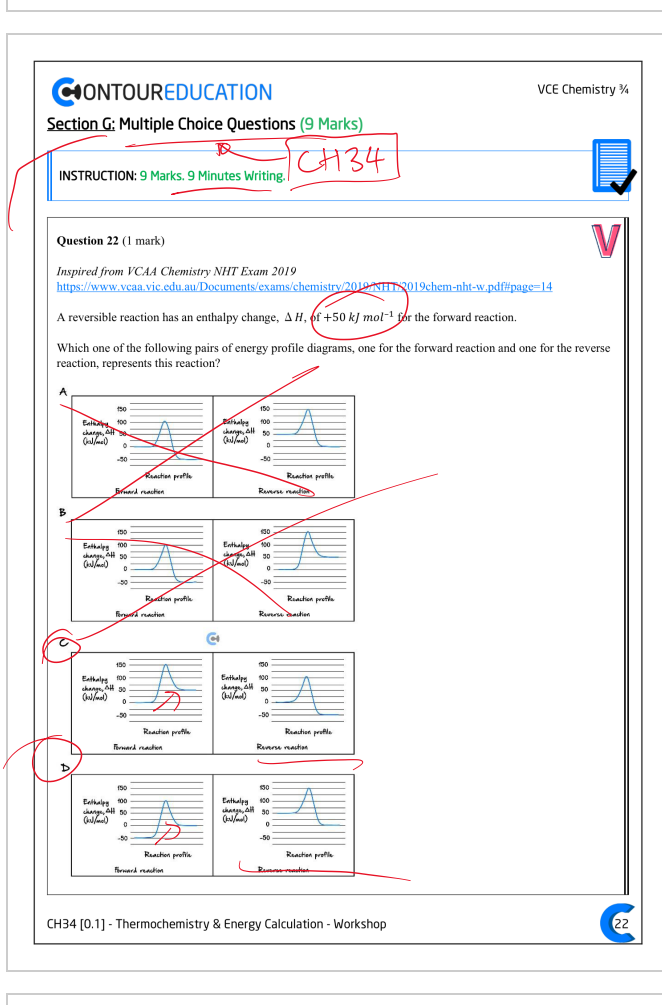


Section G: Multiple Choice Questions (9 Marks)

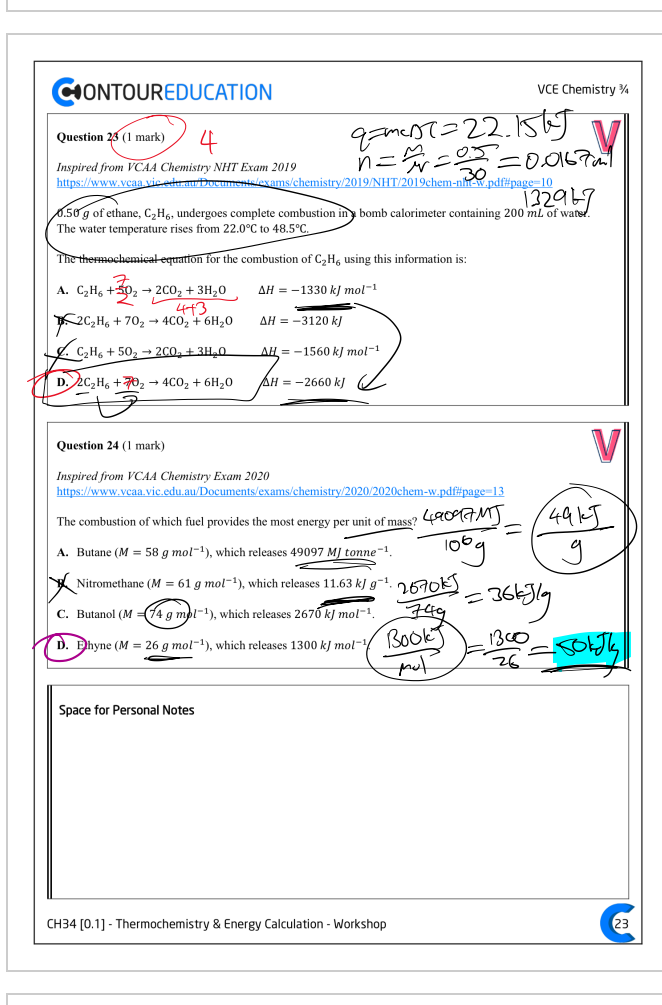
INSTRUCTION: 9 Marks. 9 Minutes Writing. CH34

Question 22 (1 mark)

Inspired from VCAA Chemistry NHT Exam 2019
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2019/NHT/2019chem-nht-w.pdf#page=14

A reversible reaction has an enthalpy change, ΔH, of $+50\ kJ\ mol^{-1}$ for the forward reaction.

Which one of the following pairs of energy profile diagrams, one for the forward reaction and one for the reverse reaction, represents this reaction?



Question 23 (1 mark) 4

Inspired from VCAA Chemistry NHT Exam 2019
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2019/NHT/2019chem-nht-w.pdf#page=10

0.50 g of ethane, C_2H_6, undergoes complete combustion in a bomb calorimeter containing 200 mL of water. The water temperature rises from 22.0°C to 48.5°C.

The thermochemical equation for the combustion of C_2H_6 using this information is:

$q = mc\Delta T = 22.15 kJ$

$n = \frac{m}{M} = \frac{0.5}{30} = 0.0167 mol$

1329kJ

A. $C_2H_6 + \frac{7}{2}O_2 \rightarrow 2CO_2 + 3H_2O \quad \Delta H = -1330\ kJ\ mol^{-1}$

B. $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O \quad \Delta H = -3120\ kJ$

C. $C_2H_6 + 5O_2 \rightarrow 2CO_2 + 3H_2O \quad \Delta H = -1560\ kJ\ mol^{-1}$

D. $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O \quad \Delta H = -2660\ kJ$

Question 24 (1 mark)

Inspired from VCAA Chemistry Exam 2020
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2020/2020chem-w.pdf#page=13

The combustion of which fuel provides the most energy per unit of mass?

A. Butane ($M = 58\ g\ mol^{-1}$), which releases 49097 $MJ\ tonne^{-1}$.

B. Nitromethane ($M = 61\ g\ mol^{-1}$), which releases 11.63 $kJ\ g^{-1}$.

C. Butanol ($M = 74\ g\ mol^{-1}$), which releases 2670 $kJ\ mol^{-1}$.

[✓ D.] Ethyne ($M = 26\ g\ mol^{-1}$), which releases 1300 $kJ\ mol^{-1}$.

$\frac{49097 MJ}{10^6 g} = \frac{49 kJ}{g}$

$\frac{2670 kJ}{74 g} = 36 kJ/g$

$\frac{1300 kJ/mol}{26} = 50 kJ/g$

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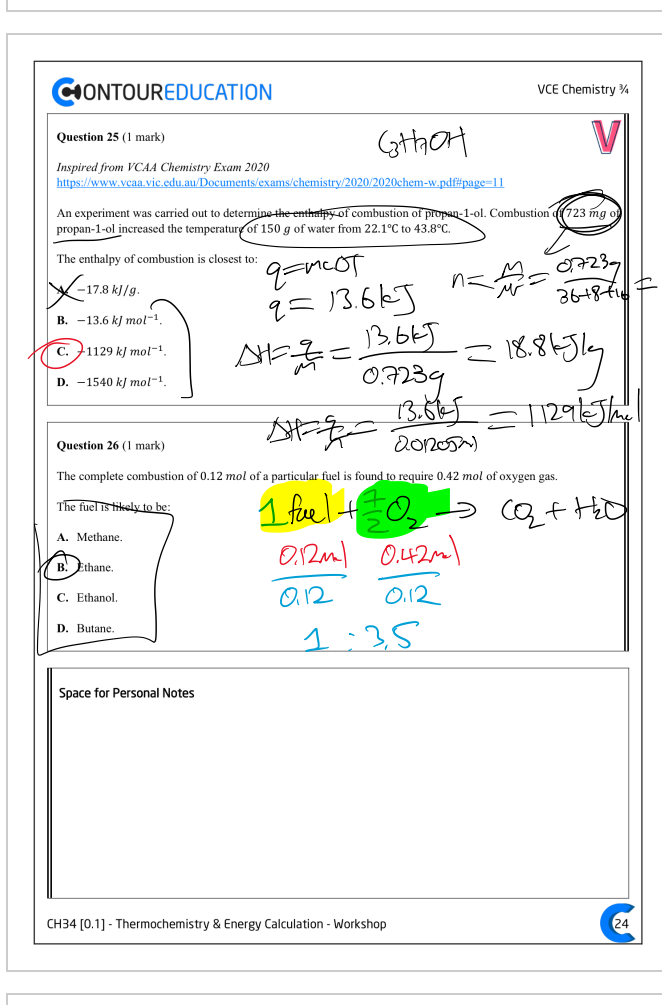

Question 25 (1 mark)

Inspired from VCAA Chemistry Exam 2020
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2020/2020chem-w.pdf#page=11

An experiment was carried out to determine the enthalpy of combustion of propan-1-ol. Combustion of 723 mg of propan-1-ol increased the temperature of 150 g of water from 22.1°C to 43.8°C.

The enthalpy of combustion is closest to:

A. $-17.8\ kJ/g$.

B. $-13.6\ kJ\ mol^{-1}$.

[✓ C.] $-1129\ kJ\ mol^{-1}$.

D. $-1540\ kJ\ mol^{-1}$.

C_3H_7OH

$q = mc\Delta T$

$q = 13.6 kJ$

$n = \frac{m}{M_r} = \frac{0.723}{36 + 8 + 16} = 0.0120 mol$

$\Delta H = \frac{q}{m} = \frac{13.6 kJ}{0.723 g} = 18.8 kJ/g$

$\Delta H = \frac{q}{n} = \frac{13.6 kJ}{0.01205 mol} = 1129 kJ/mol$

Question 26 (1 mark)

The complete combustion of 0.12 mol of a particular fuel is found to require 0.42 mol of oxygen gas.

The fuel is likely to be:

A. Methane.

[✓ B.] Ethane.

C. Ethanol.

D. Butane.

1 fuel + 3.5 O_2 → $CO_2 + H_2O$

0.12mol 0.42mol

0.12 0.12

1 : 3.5

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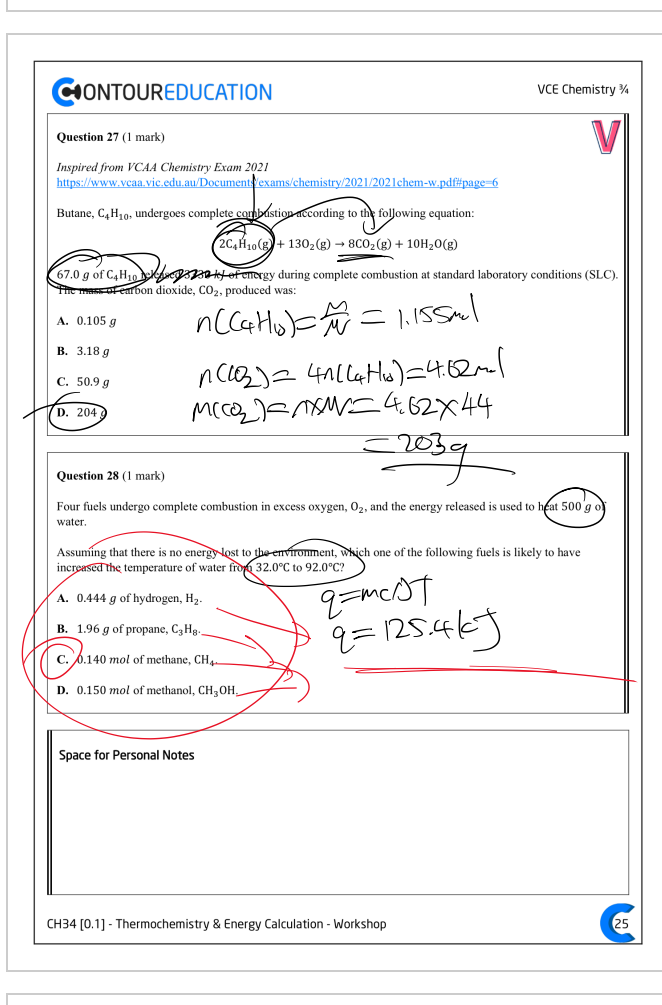

Question 27 (1 mark)

Inspired from VCAA Chemistry Exam 2021
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2021/2021chem-w.pdf#page=6

Butane, C_4H_{10}, undergoes complete combustion according to the following equation:

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

67.0 g of C_4H_{10} [illegible] of energy during complete combustion at standard laboratory conditions (SLC). The mass of carbon dioxide, CO_2, produced was:

A. 0.105 g

B. 3.18 g

C. 50.9 g

[✓ D.] 204 g

$n(C_4H_{10}) = \frac{m}{M} = 1.155 mol$

$n(CO_2) = 4n(C_4H_{10}) = 4.62 mol$

$m(CO_2) = n \times M = 4.62 \times 44$

$= 203 g$

Question 28 (1 mark)

Four fuels undergo complete combustion in excess oxygen, O_2, and the energy released is used to heat 500 g of water.

Assuming that there is no energy lost to the environment, which one of the following fuels is likely to have increased the temperature of water from 32.0°C to 92.0°C?

A. 0.444 g of hydrogen, H_2.

B. 1.96 g of propane, C_3H_8.

[✓ C.] 0.140 mol of methane, CH_4.

D. 0.150 mol of methanol, CH_3OH.

$q = mc\Delta T$

$q = 125.4 kJ$

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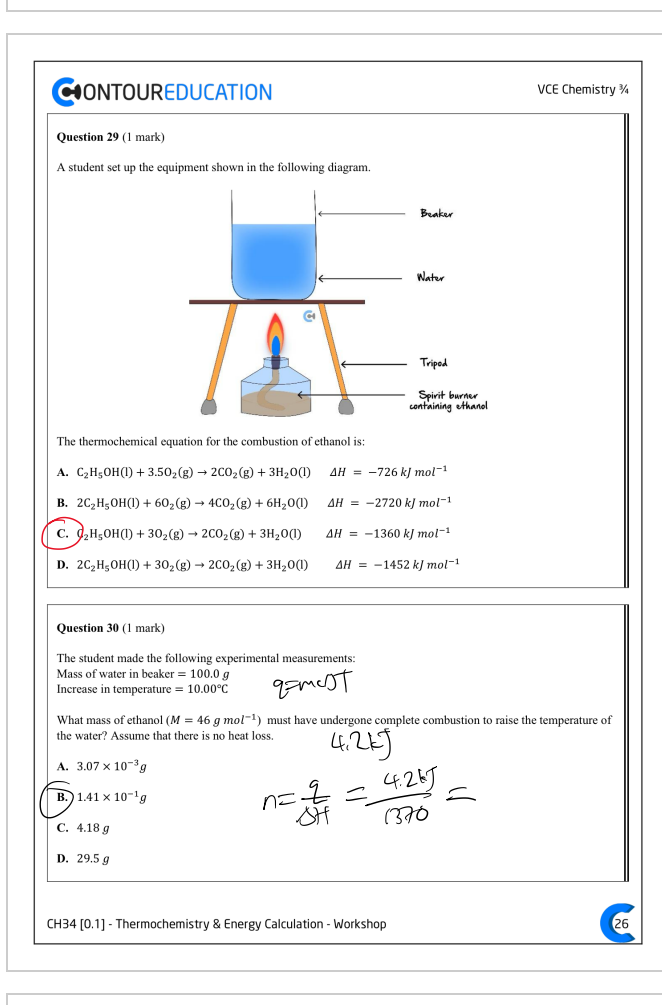


Question 29 (1 mark)

A student set up the equipment shown in the following diagram.

Beaker
Water
Tripod
Spirit burner containing ethanol

The thermochemical equation for the combustion of ethanol is:

A. $C_2H_5OH(l) + 3.5O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l) \quad \Delta H = -726\ kJ\ mol^{-1}$

B. $2C_2H_5OH(l) + 6O_2(g) \rightarrow 4CO_2(g) + 6H_2O(l) \quad \Delta H = -2720\ kJ\ mol^{-1}$

[✓ C.] $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l) \quad \Delta H = -1360\ kJ\ mol^{-1}$

D. $2C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l) \quad \Delta H = -1452\ kJ\ mol^{-1}$

Question 30 (1 mark)

The student made the following experimental measurements:
Mass of water in beaker = 100.0 g
Increase in temperature = 10.00°C

What mass of ethanol ($M = 46\ g\ mol^{-1}$) must have undergone complete combustion to raise the temperature of the water? Assume that there is no heat loss.

$q = mc\Delta T$

4.2kJ

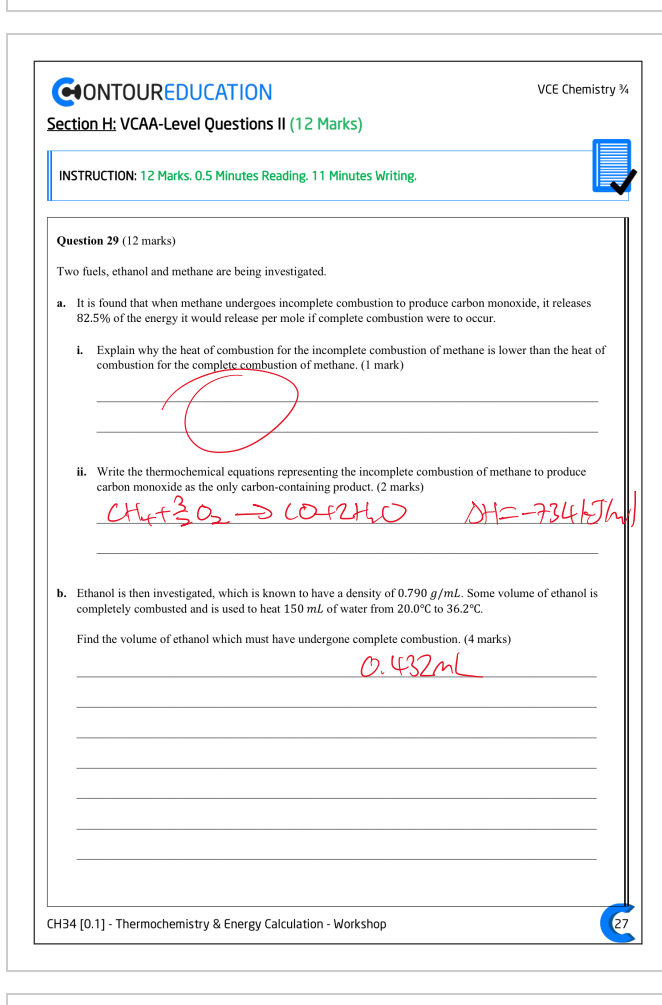
$n = \frac{q}{\Delta H} = \frac{4.2 kJ}{1370} =$

A. $3.07 \times 10^{-3} g$

[✓ B.] $1.41 \times 10^{-1} g$

C. 4.18 g

D. 29.5 g



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

INSTRUCTION: 12 Marks. 0.5 Minutes Reading. 11 Minutes Writing.

Question 29 (12 marks)

Two fuels, ethanol and methane are being investigated.

a. It is found that when methane undergoes incomplete combustion to produce carbon monoxide, it releases 82.5% of the energy it would release per mole if complete combustion were to occur.

i. Explain why the heat of combustion for the incomplete combustion of methane is lower than the heat of combustion for the complete combustion of methane. (1 mark)

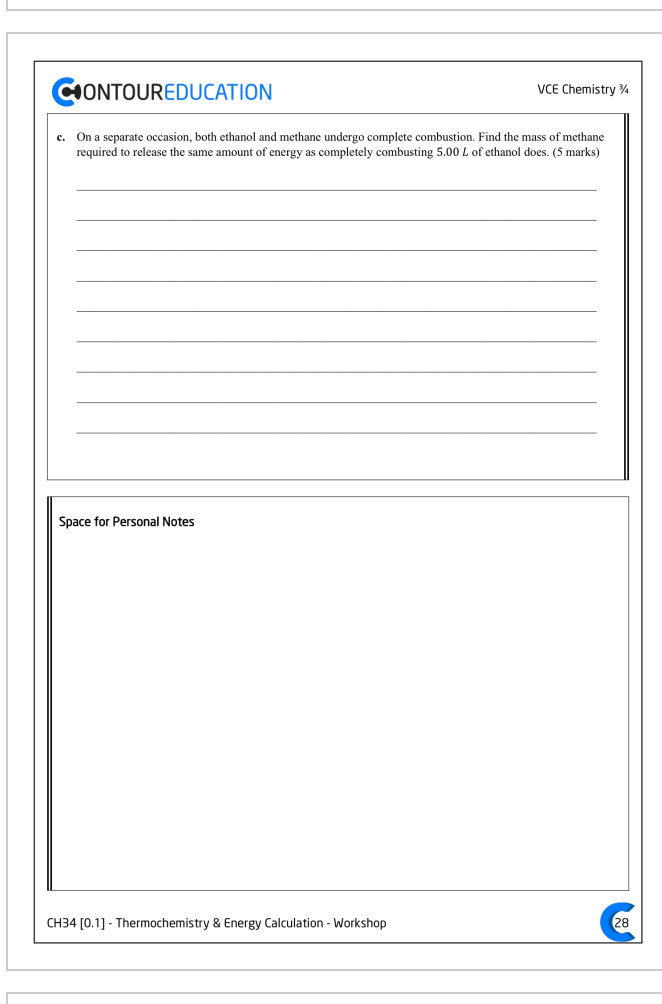
ii. Write the thermochemical equations representing the incomplete combustion of methane to produce carbon monoxide as the only carbon-containing product. (2 marks)

$CH_4 + \frac{3}{2}O_2 \rightarrow CO + 2H_2O \quad \Delta H = -734 kJ/mol$

b. Ethanol is then investigated, which is known to have a density of 0.790 g/mL. Some volume of ethanol is completely combusted and is used to heat 150 mL of water from 20.0°C to 36.2°C.

Find the volume of ethanol which must have undergone complete combustion. (4 marks)

0.432mL



c. On a separate occasion, both ethanol and methane undergo complete combustion. Find the mass of methane required to release the same amount of energy as completely combusting 5.00 L of ethanol does. (5 marks)

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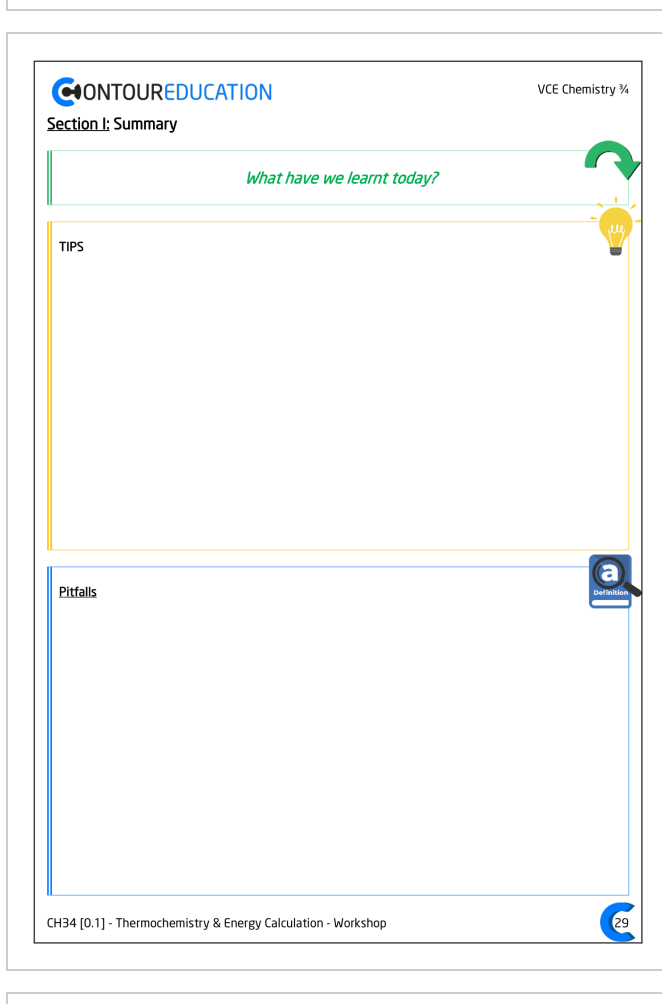
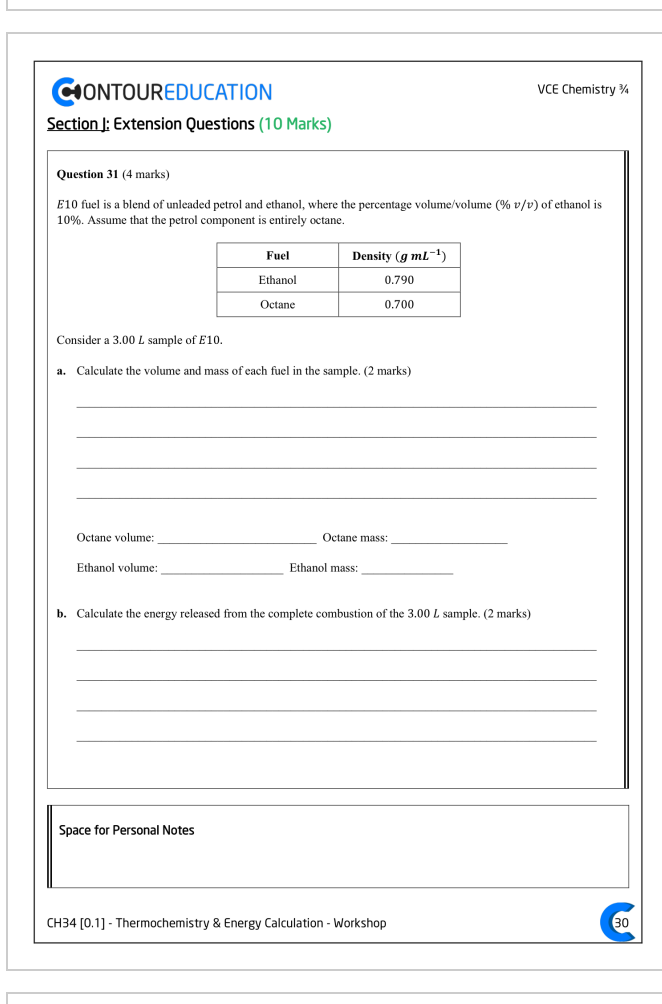


Section I: Summary

What have we learnt today?

TIPS

Pitfalls



Section J: Extension Questions (10 Marks)

Question 31 (4 marks)

$E10$ fuel is a blend of unleaded petrol and ethanol, where the percentage volume/volume ($\%\ v/v$) of ethanol is 10%. Assume that the petrol component is entirely octane.

Fuel	Density ($g\ mL^{-1}$)
Ethanol	0.790
Octane	0.700

Consider a 3.00 L sample of $E10$.

a. Calculate the volume and mass of each fuel in the sample. (2 marks)

Octane volume: ______________________ Octane mass: ________________

Ethanol volume: __________________ Ethanol mass: ____________

b. Calculate the energy released from the complete combustion of the 3.00 L sample. (2 marks)

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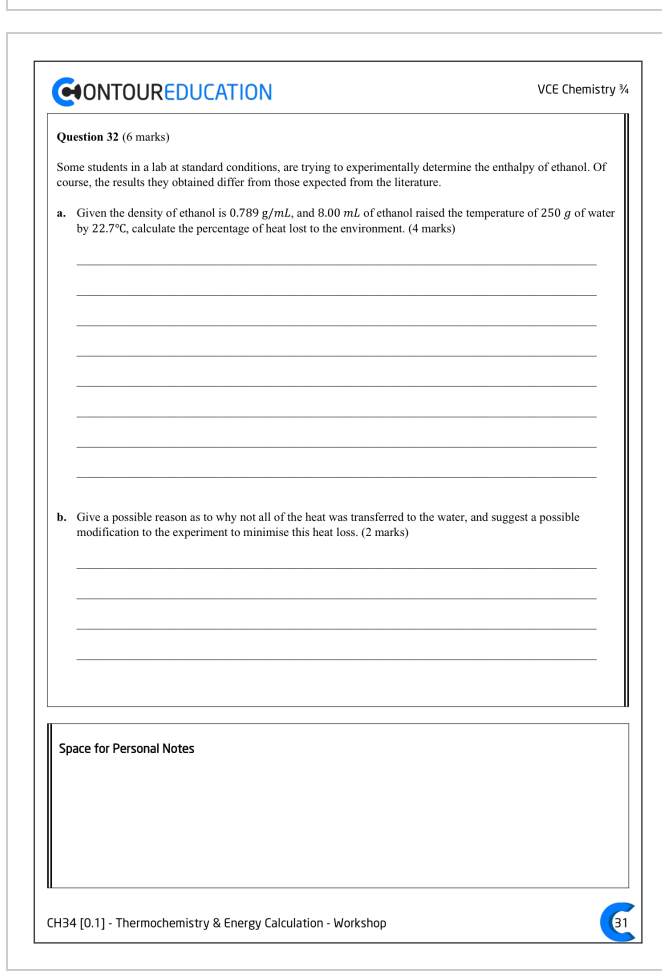

Question 32 (6 marks)

Some students in a lab at standard conditions, are trying to experimentally determine the enthalpy of ethanol. Of course, the results they obtained differ from those expected from the literature.

a. Given the density of ethanol is 0.789 g/mL, and 8.00 mL of ethanol raised the temperature of 250 g of water by 22.7°C, calculate the percentage of heat lost to the environment. (4 marks)

b. Give a possible reason as to why not all of the heat was transferred to the water, and suggest a possible modification to the experiment to minimise this heat loss. (2 marks)

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