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VCE Chemistry ¾
AOS 1 Revision I [1.11]
Contour Check

Contour Checklist

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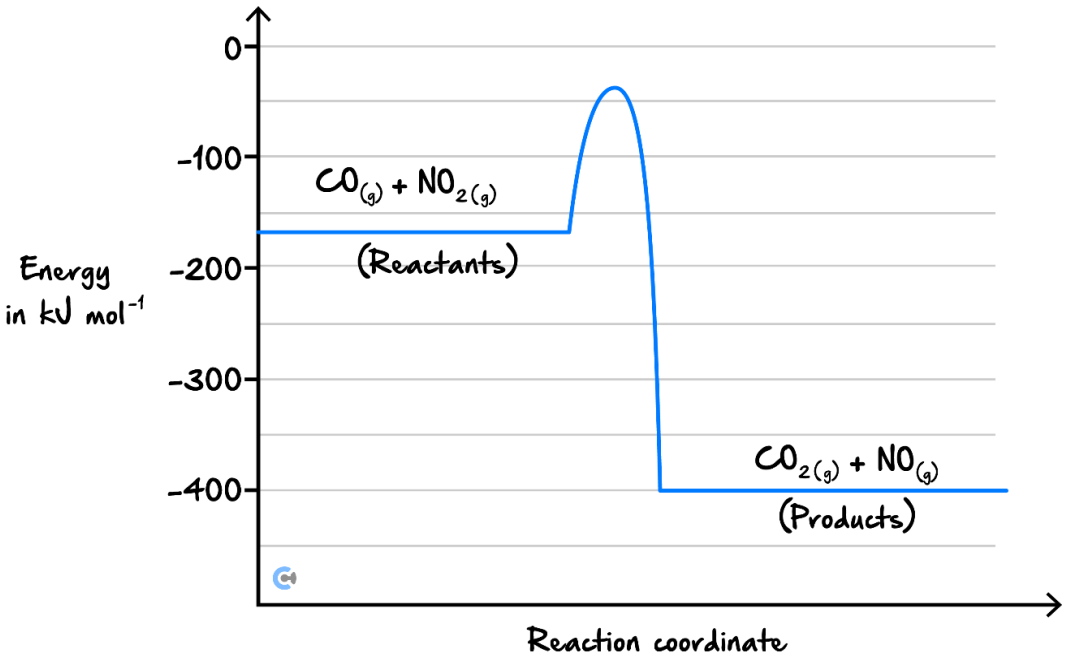
Section A: [1.1] – Thermochemistry (Checkpoints) (44 Marks)

Sub-Section: [1.1.1] Identify ΔH and E_a in Endothermic/Exothermic Energy Profile Diagrams

Question 1 (3 marks)

Consider the following energy profile diagram.

A student observes the following energy profile diagram below.



a. State whether the reaction is endothermic or exothermic. (1 mark)

_____

b. State the activation energy (kJ) required for the reaction to occur. (1 mark)

_____

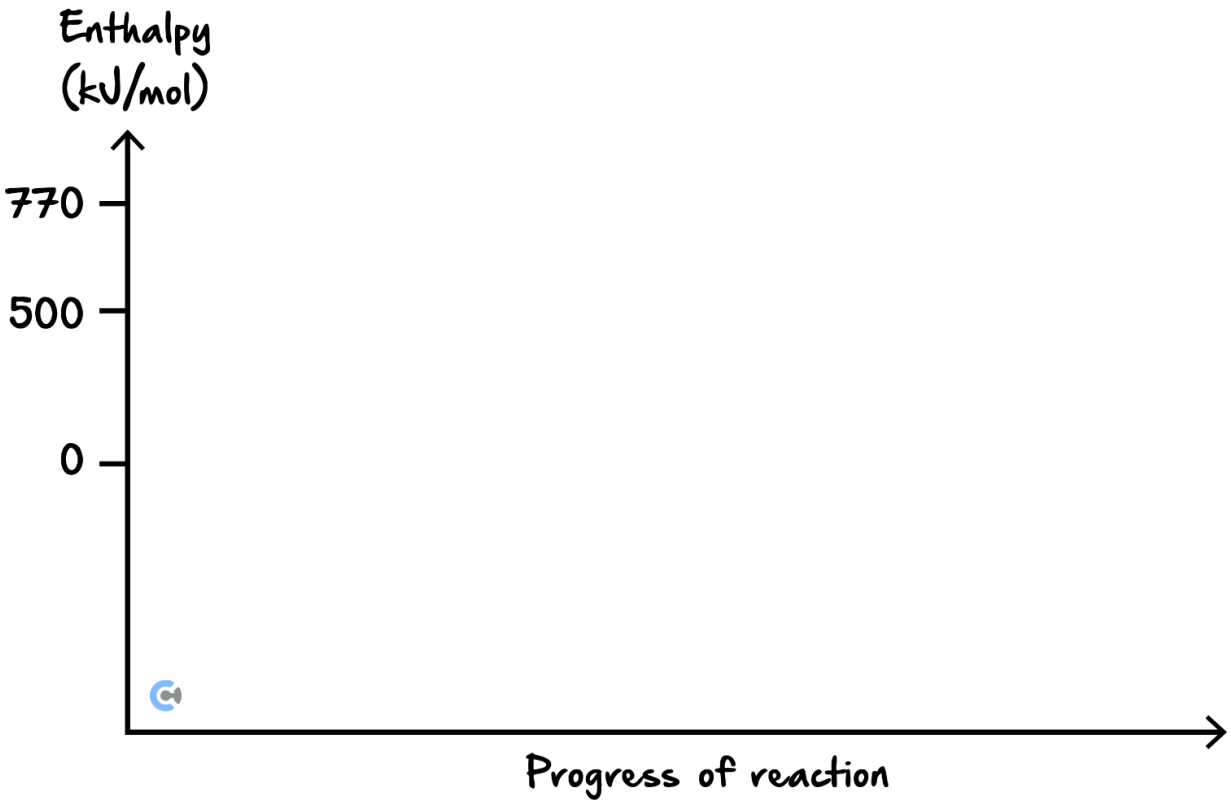
c. Calculate the ΔH value for this reaction. (1 mark)

_____

Question 2 (6 marks)

An upcoming scientist is exploring a new reaction. She notices that the energy required to break the bonds in the reactants and form the product is equal to 770 $kJ\ mol^{-1}$. Secondly, she finds that the amount of energy absorbed has a magnitude of 500 $kJ\ mol^{-1}$. Additionally, she notices the temperature of the test tube drops when this reaction occurs.

a. Draw an energy diagram showing the enthalpy of reactants and products. (2 marks)



b. Label the activation energy and change in enthalpy on the energy diagram drawn in **part b.i.** (1 mark)

c. State whether the reaction is exothermic or endothermic. (1 mark)

_____

d. Alex claims that an exothermic reaction will always have an activation energy that is always bigger in magnitude than the ΔH value, whereas James says this is only true for endothermic reactions. Determine who is correct. (**Hint**: Draw both out.) (2 marks)

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Space for Personal Notes

Question 3 (4 marks)

Kevin bruises his leg playing soccer and uses an instant ice pack to help with the inflammation. He is told that when you activate the ice pack (by snapping it), it activates a chemical reaction. The ice pack is ready to use within 30-60 seconds.

a. State the type of chemical reaction (endothermic or exothermic) occurring when the ice pack is snapped. (1 mark)

_____

b. Kevin is told that the following chemical reaction is occurring in the icepack:

$$NH_4NO_3(s) + H_2O(l) \rightarrow NH_4^+(aq) + NO_3^-(aq)$$

He is told that the ΔH value is 25.7 kJ/mol, but cannot remember if the value should be positive or negative.

State whether the value should be positive or negative. (1 mark)

_____

c. Explain the purpose of snapping the ice pack. (2 marks)

_____

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Space for Personal Notes

Sub-Section: [1.1.2] Identify Differences Between Complete and Incomplete Combustion & Write their Thermochemical Combustion Equations

Question 4 (2 marks)

Consider the following substances which have been combusted.

Write balanced thermochemical chemical equations for the following reactions:

a. The complete combustion of methane gas (CH_4). (1 mark)

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_____

b. The incomplete combustion of hexane liquid (C_6H_{14}), forming carbon byproduct, where $2220\ kJ\ mol^{-1}$ of energy is released. (1 mark)

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Space for Personal Notes

Question 5 (4 marks)

An experiment is conducted where methanol is combusted in a low-oxygen environment.

a. State the type of reaction that will occur.

b. Write a balanced chemical equation for the reaction occurring, given that no carbon monoxide is detected in the experiment. (1 mark)

c. James explains that incomplete combustion is more efficient than complete combustion, as less energy is required to obtain products. Evaluate this statement. (3 marks)

Space for Personal Notes

Question 6 (3 marks)

An experiment was conducted where $C_{20}H_{40}O_2$ was combusted, where the fuel was the excess reagent.

Following the combustion, the experimenter noticed a thick black coating along the beaker which contained the fuel. No other carbon by-products were produced.

a. Write a balanced chemical equation for the reaction. (1 mark)

_____

_____

b. State what likely caused the black residue on the beaker. (1 mark)

_____

_____

c. Predict whether the reaction was exothermic or endothermic. (1 mark)

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Question 7 (7 marks)

A complete combustion reaction occurs with ethanol, over an open Bunsen burner flame.

a. Write a thermochemical equation for the reaction occurring. (1 mark)

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b. In another experiment, the Bunsen burner hole is closed partially, causing the flame to change from blue to orange. The ethanol sample is then combusted under the open flame.

i. Explain why the colour change of the flame occurred. (2 marks)

_____

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_____

ii. Write a balanced chemical equation for the reaction occurring, given that carbon monoxide and carbon soot are produced. (1 mark)

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_____

iii. State which reactant is reacting in excess. (1 mark)

_____

c. Predict and justify whether the ΔH value for this reaction will be greater or less than that of **part a.** (2 marks)

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Space for Personal Notes

Sub-Section: [1.1.3] Apply Changing Equations to Thermochemical Equations & Energy Profile Diagrams

Question 8 (3 marks)

Consider the following thermochemical equations.

A reaction occurs, as shown in the following chemical equation:

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g) \qquad \Delta H = +129\ kJ\ mol^{-1}$$

a. Calculate the ΔH for the reaction represented by the equation: (1 mark)

$$NaHCO_3(s) \rightarrow \frac{1}{2}Na_2CO_3(s) + \frac{1}{2}H_2O(g) + \frac{1}{2}CO_2(g)$$

b. Calculate the ΔH for the reaction represented by the equation: (1 mark)

$$4NaHCO_3(s) \rightarrow 2Na_2CO_3(s) + 2H_2O(g) + 2CO_2(g)$$

c. Calculate the ΔH for the reaction represented by the equation: (1 mark)

$$3H_2O(g) + 3CO_2(g) + 2Na_2CO_3(s) \rightarrow 6NaHCO_3(s)$$

Question 9 (2 marks)

A reaction occurs, as shown in the following chemical equation:

$$2Mg(s) + O_2(g) \rightarrow 2MgO(s) \qquad \Delta H = -1204\ kJ/mol$$

a. Calculate the ΔH for the reaction represented by the equation: (1 mark)

$$4Mg(s) + 2O_2(g) \rightarrow 4MgO(s)$$

b. Calculate the ΔH for the reaction represented by the equation: (1 mark)

$$3\text{Mg(s)} + \frac{3}{2}\text{O}_2\text{(g)} \rightarrow 3\text{MgO(s)}$$

Question 10 (3 marks)

Iron (III) oxide has applications in the pharmaceutical industry. It can be produced through the reaction shown below:

$$\text{Fe}_2\text{O}_3\text{(s)} + 2\text{Al(s)} \rightarrow 2\text{Fe(l)} + \text{Al}_2\text{O}_3\text{(s)} \qquad \Delta H = -850\ kJ\ mol^{-1}$$

a. Calculate the ΔH for the reaction represented by the equation: (1 mark)

$$4\text{Fe(l)} + 2\text{Al}_2\text{O}_3\text{(s)} \rightarrow 2\text{Fe}_2\text{O}_3\text{(s)} + 4\text{Al(s)}$$

b. Calculate the ΔH for the reaction represented by the equation, and find the value of the coefficient 'x'. (2 marks)

$$\frac{1}{6}\text{Fe(l)} + \frac{1}{12}\text{Al}_2\text{O}_3\text{(s)} \rightarrow \frac{1}{12}\text{Fe}_2\text{O}_3\text{(s)} + x\text{Al(s)}$$

Space for Personal Notes

Question 11 (7 marks)

Anna is combusting a sample of $C_5H_{11}OH(l)$ over a Bunsen burner flame. If combusted completely, for every mole of pentanol, $3256\ kJ$ of energy is released.

a. Given that a complete combustion reaction occurs, write a balanced chemical equation for the reaction. (1 mark)

b. State whether the reaction is exothermic or endothermic. Justify your response. (2 marks)

c. Anna is trying to determine the chemical equation from the following ΔH values.

i. $\Delta H = +3256\ kJ/mol$. (1 mark)

ii. $\Delta H = -6512\ kJ/mol$. (1 mark)

iii. $\Delta H = -2170.67\ kJ/mol$. (2 marks)

Space for Personal Notes

Section B: [1.2] – Energy Calculations & ΔH (Checkpoints) (39 Marks)

Sub-Section [1.2.1]: Apply $\Delta H = q \times n$ to find Energy Released

Question 12 (2 marks)

a. How much energy (in kilojoules) is released when 3.50 moles of hydrogen is combusted completely? (1 mark)

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_____

b. A sample contains 1.25 moles of carbon (graphite). How much energy (in kilojoules) is released when the carbon is combusted? (1 mark)

_____

_____

Question 13 (2 marks)

Calculate the energy released when 10.0 grams of glucose ($C_6H_{12}O_6$) are combusted.

_____

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Space for Personal Notes

Question 14 (3 marks)

A sample contains 12.0 g of butane and 8.0 g of hydrogen gas. Calculate the total energy released when both are combusted.

Question 15 (4 marks)

A 50/50 by-mass fuel mixture of ethanol and methane is combusted completely. If the total mass of the mixture is 20.0 g, calculate the total energy released.

Space for Personal Notes

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

Question 16 (1 mark)

A generator burns 15.0 mL of petrol to produce energy. Calculate the total energy released during this process.

Question 5 (4 marks)

a. The density of butan-1-ol is 0.745 g/mL, calculate the amount of energy that will be released by 1.50 L of butan-1-ol given its molar heat of combustion is 37.8 kJ/g. (2 marks)

b. A mixture of 3.00 g of ethane and 2.00 g of carbon is combusted. Calculate the total energy released in kJ. (2 marks)

Space for Personal Notes

Question 6 (3 marks)

The density of octane is 0.703 g/mL under SLC.

a. Calculate the amount of energy released by a canister containing 20.0 L of octane when it undergoes complete combustion. (1 mark)

b. Determine the volume of octane required to release 1.5 kJ of energy. (2 marks)

Question 17 (3 marks)

A ship uses 50.0 kg of kerosene during a trip.

a. Calculate the total energy released from combusting the kerosene in megajoules. (1 mark)

b. Calculate the volume, in litres, of kerosene used during the trip. (2 marks)

Space for Personal Notes

Sub-Section [1.2.3]: Apply $q = mcAT$ to Find Energy Absorbed

Question 18 (1 mark)

Calculate the amount of heat energy, in kJ, required to heat up a kettle containing 1.5 L of water from 25°C to 100°C.

Question 19 (1 mark)

If 21.7 kJ of energy was inputted to a pot of water to increase the temperature from 14.0°C to 44.4°C, find the volume of water which was present.

Question 20 (3 marks)

A sample of water with a volume of 500 mL at SLC absorbs 20.9 kJ of energy. Find the final temperature of the water.

Sub-Section [1.2.4]: Calculate ΔH Experimentally

Question 21 (3 marks)

A particular spirit burner contained a sample of an unknown fuel. It is used to heat up a beaker containing 150 mL of water. The following data was obtained:

- The initial mass of the spirit burner: 100 mL
- The final mass of the spirit burner: 98.5 mL
- The initial temperature of water: 25℃
- The final temperature of water: 37℃

a. Calculate the volume of the unknown fuel that underwent combustion. (1 mark)

_____

b. Determine the amount of energy absorbed by the water, in kJ. (1 mark)

_____

_____

c. Calculate the heat of combustion of the unknown fuel in $kJ\ mol^{-1}$. (1 mark)

_____

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Space for Personal Notes

Question 22 (4 marks)

A burner containing ethanol (C_2H_5OH) is used to heat 200.0 g of water. The water temperature rises from 20.0℃ to 45.0℃. The initial mass of the burner and ethanol is 120.50 g, and the final mass is 119.75 g. Calculate the experimental heat of combustion of ethanol in kJ/mol.

Space for Personal Notes

Question 23 (5 marks)

A student uses ethanol (C_2H_5OH) to heat 300.0 g of water. The water's temperature increases from 22.0℃ to 52.0℃. The initial volume of ethanol is 25.0 mL, and the final volume is 22.5 mL. The density of ethanol is 0.789 g/mL.

Calculate the experimental heat of combustion of ethanol in kJ/mol.

Space for Personal Notes

Section C: [1.3] – Gas Calculations & Stoichiometry (Checkpoints) (69 Marks)

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

Question 24 (2 marks)

An experiment involves a butane canister containing 5.00 g of butane.

a. Assuming excess oxygen, what is the amount of energy released in kJ if the molar heat of the combustion of butane is $-2880\ kJ\ mol^{-1}$? (1 mark)

b. Later 2.00 g of ethanol was combusted, given that the molar heat of combustion of ethanol is $-1370\ kJ\ mol^{-1}$, calculate the amount of energy released during its combustion. (1 mark)

Question 25 (3 marks)

A sample of propanol in a spirit burner initially weighs 95.80 g. After complete combustion, the spirit burner weighs 93.45 g. The heat energy released is used to heat 400 mL of water at SLC. The temperature of the water rises from 22.00℃ to 48.50℃.

Calculate the heat of combustion of propanol in $kJ\ mol^{-1}$.

Question 26 (3 marks)

A sample of ethanol in a spirit burner initially weighs 60.00 g. After complete combustion, the spirit burner weighs 50.50 g. The heat energy released is used to heat 500 mL of water at SLC. The temperature of the water rises from 25.00℃ to 60.00℃.

Calculate the heat of combustion of ethanol in $kJ\ mol^{-1}$ and state its energy efficiency.

Question 27 (6 marks)

In the pharmaceutical industry, there is a particular compound that is highly desired. Its production involves a two-step process, whereby an intermediate product ($C_{15}H_{22}O$) is first produced, and then converted into the final product ($C_{30}H_{40}O_4$). The final product is produced via the following reaction:

$$2C_{15}H_{22}O + 2O_2 \rightarrow C_{30}H_{40}O_4 + 2H_2O$$

a. Given 10.0 mol of $C_{15}H_{22}O$ is reacted, calculate the final amount in grams of $C_{30}H_{40}O_4$ produced. (2 marks)

b. In practice, both reactions are 75% efficient.

i. Hence, calculate the amount of mol of $C_{30}H_{40}O_4$ that will be produced given 10.0 mol of $C_{15}H_{22}O$ is reacted. (2 marks)

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_____

_____

ii. Using your response to the previous question, explain whether in practice the final mol, or the final mass of $C_{30}H_{40}O_4$ will be affected. (2 marks)

_____

_____

Space for Personal Notes

Sub-Section [1.3.2]: Apply $n = V/V_m$ to Calculate Volumes of Gas at SLC

Question 28 (2 marks)

For the following scenario, assume everything occurs at SLC.

a. Find the amount, in mol, of 6.00 L of ammonia gas, NH_3. (1 mark)

_____

b. Find the volume that 10.00 g of sulphur dioxide occupies. (1 mark)

_____

_____

Question 29 (3 marks)

A sample of 20.5 g of propane is being investigated.

a. Determine the volume that propane will occupy at SLC. (1 mark)

_____

_____

b. Another sample of oxygen gas weighing 96.0 g is also added to the propane. Determine the volume that the mixture of both gases will occupy at SLC. (2 marks)

_____

_____

Space for Personal Notes

Question 30 (4 marks)

A gas canister containing 30.0 L of methane is used in a portable stove.

a. Calculate the amount of energy that will be released given the entire gas canister undergoes complete combustion at SLC. (2 marks)

_____

_____

b. The same 30.0 L canister is filled half with liquid methane that has a density of 0.415 $g\ L^{-1}$. The other half of the canister is filled with gaseous methane. Calculate the potential amount of energy, if all the liquid and gas methane underwent combustion. (2 marks)

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Question 31 (6 marks)

Ammonia gas (NH_3) is a versatile compound used as a fertiliser in agriculture, a key ingredient in nitric acid production, and a refrigerant. Its applications extend to pharmaceutical synthesis and cleaning agents. Despite its pungent odour and toxicity, ammonia gas plays a key role in agriculture, industry, and various industrial processes.

a. Calculate the volume that a sample of 20.0 g of ammonia gas (NH_3) will occupy at SLC. (1 mark)

_____

b. Determine the volume that 15.70 mol of ammonia gas will occupy at SLC. (1 mark)

_____

c. Now, consider the reaction involving ammonia that occurs at SLC:

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$$

i. If there was 12.50 *L* of ammonia that reacts, calculate the total mass of products made. (3 marks)

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_____

_____

_____

ii. What type of data would you need if the reaction was not at SLC to convert from volume to moles? (1 mark)

_____

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Space for Personal Notes

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

Question 32 (3 marks)

Hydrogen gas reacts with nitrogen gas to produce ammonia, as represented by the equation:

$$3H_2(g) + N_2(g) \rightarrow 2NH_3(g)$$

If 12.0 L of hydrogen gas reacts completely with nitrogen gas at SLC:

a. What volume of nitrogen gas is required? (1 mark)

_____

b. What volume of ammonia is produced? (2 marks)

_____

_____

Question 33 (3 marks)

The decomposition of potassium chlorate produces oxygen gas:

$$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$

a. How many moles of oxygen gas are produced when 5.00 g of potassium chlorate decomposes? (2 marks)

_____

_____

_____

b. Calculate the total volume of oxygen gas produced at SLC. (1 mark)

_____

Question 34 (5 marks)

Methane reacts with chlorine gas to produce dichloromethane and hydrochloric acid according to the following equation:

$$CH_4(g) + 2Cl_2(g) \rightarrow CH_2Cl_2(g) + 2HCl(g)$$

a. If 2.50 g of methane reacts, what is the mass of chlorine gas required? (2 marks)

b. Calculate the total volume of gases produced in the reaction if the reaction occurs at SLC. (2 marks)

c. Determine the total number of molecules of hydrochloric acid produced. (1 mark)

Space for Personal Notes

Question 35 (7 marks)

Ethene combusts in oxygen to produce carbon dioxide and water: Two experiments were completed using this reaction:

$$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$$

a. The first experiment used $4.50\ g$ of ethene.

i. If the ethene is combusted completely, determine the moles of oxygen gas required. (2 marks)

ii. Calculate the total volume of reactants consumed at SLC. (2 marks)

iii. What volume of carbon dioxide is produced at SLC? (1 marks)

b. The second experiment used $4.50\ L$ of ethene.

Now, determine the volume of carbon dioxide gas produced at SLC. (2 marks)

Space for Personal Notes

Sub-Section [1.3.4]: Identify Limiting Reagents

Question 36 (2 marks)

Hydrochloric acid reacts with sodium carbonate according to the following equation:

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

A reaction is set up using 7.30 g of sodium carbonate and 1.0 L of 0.05 M hydrochloric acid.

Determine the excess and limiting reagent.

Question 37 (5 marks)

Propane undergoes complete combustion according to the following equation:

$$C_3H_8(g) + 5O_2(g) \rightarrow 3\,CO_2(g) + 4H_2O(l)$$

8.8 g of propane reacts with 25.0 L of oxygen gas at SLC.

a. Find the limiting reagent. (2 marks)

b. Calculate the mass of carbon dioxide produced. (1 mark)

c. Calculate the mass of the excess reagent left over. (2 marks)

_____

_____

_____

Question 38 (7 marks)

Zinc reacts with hydrochloric acid according to the following equation:

$$Zn(s) + 2HCl(q) \rightarrow ZnCl_2(aq) + H_2(g)$$

A reaction is carried out by mixing 6.50 g of zinc with 120.0 mL of 2.0 M hydrochloric acid.

a. Determine the limiting reagent. (2 marks)

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_____

b. Calculate the total volume of gases produced in the reaction if the reaction occurs at SLC. (2 marks)

_____

c. Determine the total volume of hydrogen gas produced. (1 mark)

_____

_____

d. Calculate the mass of the excess reagent left over. (2 marks)

_____

_____

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Question 39 (8 marks)

Given the following reaction:

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

A sample of 8.00 L of methane is mixed with 20.0 L of oxygen gas at SLC.

a. Identify the excess and limiting reagents. (3 marks)

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_____

_____

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b. Calculate the mass, in g, of excess reagent left unreacted. (2 marks)

_____

_____

_____

c. Determine the total volume of carbon dioxide gas produced at SLC. (1 mark)

_____

d. Suppose the reaction occurs with the prescribed amounts, then what is the total volume of gas left over at the end, assuming that the water is completely converted to gas at the end? (2 marks)

_____

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Space for Personal Notes

Section D: [1.4] – Calorimetry (Checkpoints) (56 Marks)

Sub-Section [1.4.1]: Calculate Calibration Factor via Electrical & Chemical Calibration $\left(CF = \frac{E}{\Delta T}\right)$

Question 40 (2 marks)

Jamie passes 410 J of electrical energy through a solution calorimeter. The temperature rise of the solution is recorded as 1.8°C.

a. Determine the calibration factor for the calorimeter in $J/°C$. (1 mark)

_____

_____

b. Convert this calibration factor into $kJ/°C$. (1 mark)

_____

_____

Space for Personal Notes

Question 41 (3 marks)

Angela is experimenting with a solution calorimeter containing 250 mL of water. She applies 3.50 mA of current through the instrument for 1.50 hours, whilst the voltage remains at 1.50 V. Interestingly, she finds that the temperature of the water changes from 24.2°C to 24.5°C. Calculate the calibration factor of the calorimeter in $kJ/°C$.

Question 42 (3 marks)

A solution calorimeter is calibrated using 120.0 mL of 1.00 M H_2SO_4 mixed with excess KOH at an initial temperature of 26.0°C. The reaction is as follows:

$$H_2SO_4(aq) + 2KOH(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l) \quad \Delta H = -114.0\ kJ/mol$$

The final temperature of the calorimeter is 35.0°C. Calculate the calorimeter's calibration factor in $J/°C$.

Space for Personal Notes

Question 43 (10 marks)

A calorimeter containing 200 mL of water is calibrated using both electrical and chemical methods.

A current of 3.00 A flows through the calorimeter for 5.00 minutes at a voltage of 4.50 V. There is an increase of 8.15°C in the temperature.

a. Calculate the energy transferred into the calorimeter. (1 mark)

b. Calculate the electrical calibration factor. (2 marks)

Next, 50.0 mL of 1.00 M H_2SO_4 is reacted with 50.0 mL of 3.00 M KOH in the calorimeter.

The reaction is:

$$H_2SO_4(aq) + 2KOH(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l) \quad \Delta H = -56.0\ kJ/mol$$

The temperature rises from 25.0°C to 33.5°C.

c. Calculate the chemical calibration factor. (3 marks)

d. Compare the electrical and chemical calibration factors and make a conclusion on which calibration method is more efficient. (2 marks)

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_____

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_____

e. Combine the calibration results from both methods to calculate an average calibration factor for the calorimeter in $kJ/°C$. (2 marks)

_____

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Space for Personal Notes

Sub-Section [1.4.2]: Apply Calibration Factor to Find Energy Released ($E = CF \times \Delta T$)

Question 44 (3 marks)

A calorimeter has a known calibration factor of 51.5 $J/°C$. Calculate the energy released, in J, in the following cases:

a. If the temperature change is 3.0°C. (1 mark)

_____

_____

b. If the temperature change is 7.0°C. (1 mark)

_____

_____

c. If the temperature increases from 45.5°C to 53.0°C. (1 mark)

_____

_____

Space for Personal Notes

Question 45 (3 marks)

Liam uses a calorimeter with a calibration factor of $40.5\ J/°C$ and fills it with $250.0\ mL$ of an unknown solution. During an experiment, when a piece of steak is placed into the calorimeter, the temperature rises from 30.0°C to 43.5°C.

a. Calculate the energy released by the steak in kJ. (2 marks)

b. Given that the steak weighs $20.0\ g$, compute its energy content in kJ/g. (1 mark)

Question 46 (4 marks)

A solution calorimeter was calibrated by applying a current of $6.00\ A$ for 10.00 minutes at a voltage of $12.00\ V$. During calibration, the water's temperature increased from 20.5°C to 30.0°C. This calorimeter was later used to determine the heat content of a sample of cereal. A $4.00\ g$ cereal sample caused the temperature to increase by 14.0°C. Calculate the energy content of the cereal in kJ/g.

Question 47 (7 marks)

A complex calorimeter has a calibration factor of $45.0\ J/°C$. The calorimeter has two compartments: a water and an unknown aqueous solution compartment. During an experiment:

- A $300\ mL$ aqueous solution experiences a temperature increase from 23.0°C to 42.0°C when a $12.0\ g$ sample of fuel is burned.
- At the same time, a $150\ mL$ water compartment in the calorimeter increases in temperature by 3.50°C.
- The calorimeter itself has a heat capacity of $200.0\ J/°C$ and its temperature also rises from 23.0°C to 42.0°C.

a. Calculate the total energy released by the fuel. (4 marks)

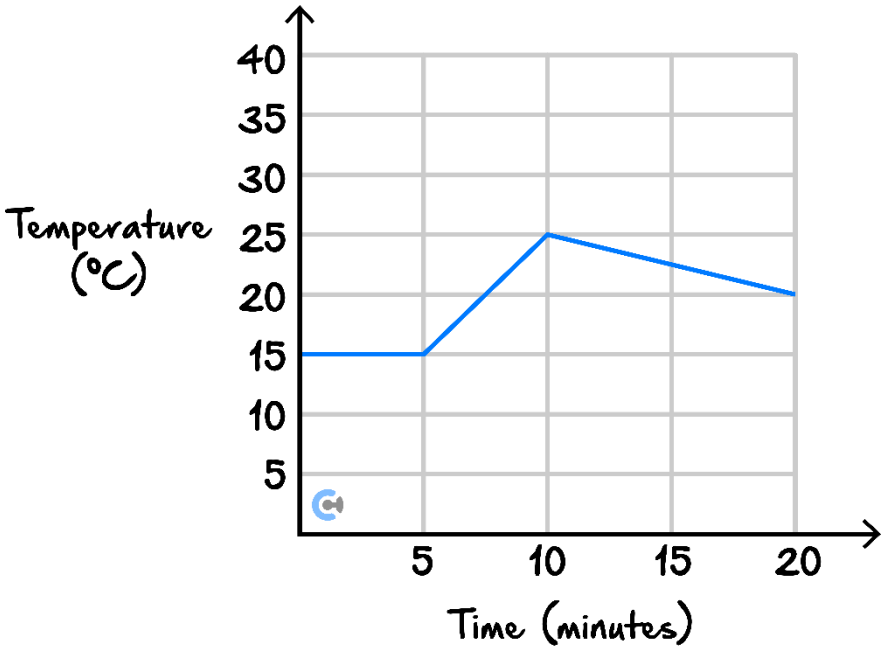
b. Determine the energy content of the fuel in kJ/g. (1 mark)

c. Sally, when analysing the calorimeter, notices that the temperature of the solution is not evenly distributed. She notices that closer to the centre, the solution is quite warm but cooler towards the peripheries. Suggest and justify an improvement that could be made to the calorimeter. (2 marks)

Sub-Section [1.4.3]: Apply Temperature-Time Graphs to Calorimetry

Question 48 (2 marks)

Alex is experimenting with a calorimeter. It is turned on at 5 minutes and switched off at 10 minutes.



a. From the graph, determine the temperature change in the calorimeter when it is turned on. (1 mark)

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b. If 180 *J* of energy is released during calibration, calculate the calorimeter's calibration factor. (1 mark)

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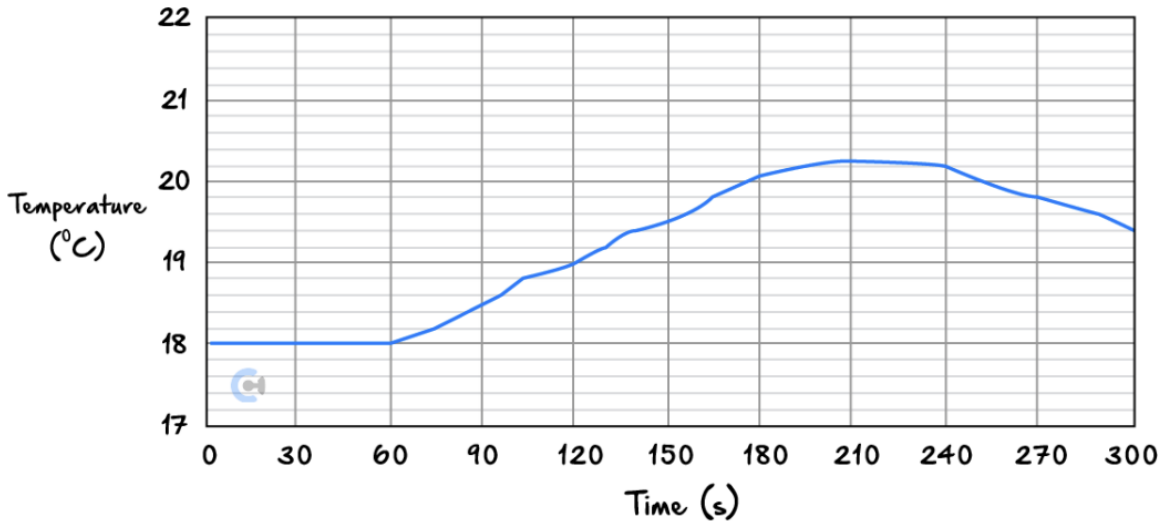
Question 49 (3 marks)

A calorimeter is calibrated with a current of 3.00 A and a voltage of 6.00 V. The heater operates from $t = 60.0$ seconds.



a. Predict when the heater in the calorimeter is turned off.

b. Determine the energy released during the calibration process. (2 marks)

c. Using the graph, compute the temperature change during calibration.

d. Calculate the calorimeter's calibration factor in $kJ/°C$. (1 mark)

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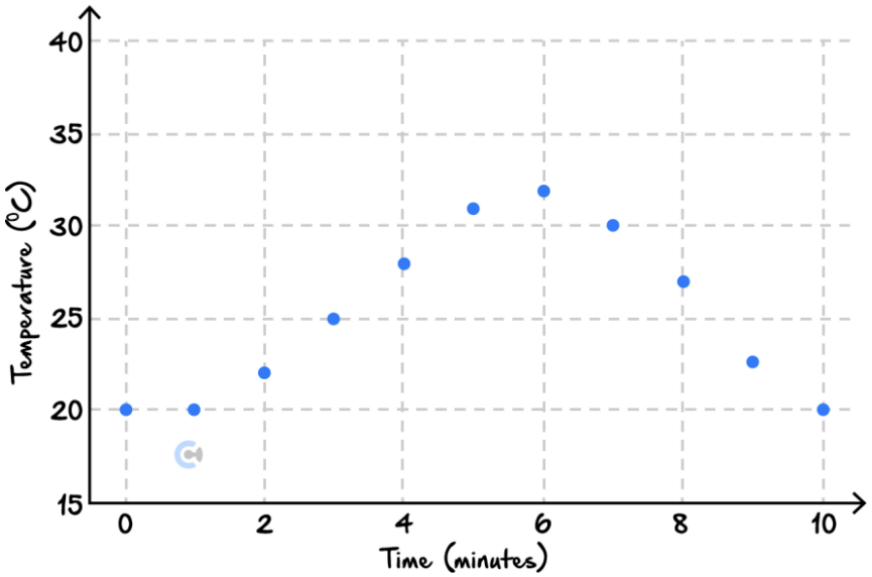
Question 50 (7 marks)

A 5.00 g sample of glucose is dissolved in water and reacts with oxygen in a calorimeter containing 200 mL of water at an initial temperature of 24°C. The reaction is as follows:

$$C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l) \quad \Delta H = -2800\ kJ/mol$$

The temperature-time graph for this reaction is provided:



When the reaction is completed, the temperature of the calorimeter is 45°C.

a. Determine the calibration factor for this calorimeter in $kJ/°C$. (3 marks)

b. Emma claims that "*Based on the graph, it is evident that the calorimeter is poorly designed to conserve energy.*" Evaluate this claim. (2 marks)

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c. Suggest 2 ways in which the design of the calorimeter could be improved. (2 marks)

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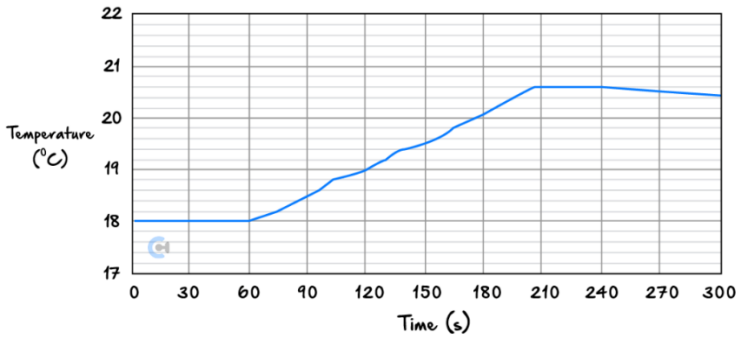
Question 51 (9 marks)

A bomb calorimeter is calibrated by passing a current of 3.50 A at a voltage of 6.20 V for 150 seconds.



a. From the temperature-time graph provided, determine the calorimeter's calibration factor in $kJ/°C$. (3 marks)

The calorimeter is then used to analyse the combustion of a 2.00 g sample of fuel, which increases the calorimeter's temperature by 15.5°C. During this combustion, it is noted that:

- A separate 100 mL water compartment outside the calorimeter absorbs 4.00 kJ of heat.
- The calorimeter itself has a heat capacity of 200 $J/°C$, which also absorbs heat during combustion.

b. Calculate the total energy released by the fuel. (3 marks)

c. Calculate the energy content of the fuel in kJ/g. (1 mark)

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d. Explain whether this calorimeter has good or poor insulation. (2 marks)

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Section E: [1.5] – Fuels (Checkpoints) (64 Marks)

Sub-Section [1.5.1]: Explain the Production of Biofuels (Biogas, Bioethanol & Biodiesel)

Question 52 (4 marks)

a. Describe one method through which biogas production helps reduce greenhouse gas emissions. (2 marks)

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b. State how the breakdown of glucose by yeast results in a usable fuel source. (2 marks)

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Question 53 (4 marks)

a. Discuss why anaerobic digestion is more sustainable than landfill decomposition for waste management. (2 marks)

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b. Propose how agricultural residues could be converted into bioethanol and explain the advantage of this approach. (2 marks)

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Question 54 (5 marks)

a. Explain why glycerol is produced during the synthesis of biodiesel and suggest one industrial use for this byproduct. (2 marks)

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b. Compare the feedstocks for producing biogas, bioethanol, and biodiesel, and evaluate which feedstock has the least environmental impact. (3 marks)

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Question 55 (7 marks)

Evelyn is experimenting with methane.

a. She is interested in the methods to source methane. Her friend suggests using crude oil as a source of methane. State another 3 non-renewable methods of obtaining methane. (2 marks)

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b. Deciding on crude oil, Evelyn is unsure of how to obtain methane from crude oil. State the process used in this separation and how it works. (3 marks)

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c. State and explain an alternative renewable method of obtaining methane gas. (2 marks)

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Sub-Section [1.5.2]: Identify & Explain Differences Between Fossil Fuels & Biofuels with Reference to Renewability

Question 56 (4 marks)

a. Define "renewable fuel" and explain why firewood from a sustainably managed forest fits this definition. (2 marks)

b. Name two fossil fuels and explain why their rate of consumption exceeds their natural replenishment rate. (2 marks)

Question 57 (4 marks)

a. Justify why bioethanol derived from sugarcane is often labelled "carbon neutral", referencing photosynthesis and combustion. (2 marks)

b. Discuss how the heat of combustion differs between fossil fuels and biofuels, considering the molecular composition of each. (2 marks)

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Question 58 (4 marks)

a. Contrast the carbon emission profiles of burning natural gas versus biogas. (2 marks)

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b. List two factors during biofuel production that compromise its carbon neutrality and suggest solutions to mitigate these effects. (2 marks)

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Question 59 (6 marks)

a. Compare and justify the rate of replenishment of biofuels and fossil fuels. State the relationship between a renewable resource and its rate of replenishment. (4 marks)

b. Fossil fuels and biofuels both release CO_2 when burned. Despite this, why are biofuels considered more environmentally friendly in terms of CO_2 emissions? (2 marks)

Space for Personal Notes

Sub-Section [1.5.3]: Write Cellular Respiration & Photosynthesis Equations

Question 60 (1 mark)

State how sunlight can be absorbed in photosynthesis.

Question 61 (2 marks)

Angela is talking with her classmates and overhears that "in cellular respiration, energy is absorbed." Evaluate this statement.

Question 62 (5 marks)

During photosynthesis, plants undergo the following reaction:

$$6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g) \qquad \Delta H = +3000\ kJ$$

a. If **$75.0\ L$ of carbon dioxide** is absorbed, what is the mass of glucose produced during photosynthesis? (3 marks)

b. How much energy is absorbed during this process? (2 marks)

Question 63 (7 marks)

a. Write the balanced chemical equations for aerobic respiration and fermentation in yeast and explain the key differences between the two processes. (3 marks)

b. If 4 moles of glucose undergo fermentation in yeast, calculate:

i. The moles of ethanol (C_2H_5OH) produced. (1 mark)

ii. The moles of carbon dioxide produced. (1 mark)

c. Compare and justify the energy output of aerobic respiration and fermentation. (2 marks)

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Sub-Section [1.5.4]: Calculate Energy Obtained from Foods

Question 64 (2 marks)

Fill in the table below.

Food	**Heat of combustion (kJg^{-1})**
Fats and oils	
Protein	
Carbohydrate	

Question 65 (2 marks)

Julian is looking at food labels and notices that kJ/g rather than kJ/mol to describe the heat of combustion of foods. Justify this observation.

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Space for Personal Notes

Question 66 (3 marks)

Emma is investigating the effect of ingestion of fibres such as cellulose in the body. State and justify what happens to cellulose during digestion.

Question 67 (4 marks)

The label on a packet of some biscuits, which has a serving size of $\mathbf{60.0}\ \boldsymbol{g}$, has the following composition:

- **Protein**: 8.25 g
- **Fats**: 2.10 g
- **Carbohydrates – sugars and starches**: 42.0 g
- **Carbohydrates – cellulose fibre**: 4.65 g

a. Calculate the total possible energy available to the body per gram of biscuit. (3 marks)

b. A sample of biscuit is combusted in a calorimeter to determine its energy value. The result obtained indicates that the energy content of the biscuit is $\mathbf{19}\ \boldsymbol{kJ/g}$. Explain why there is a difference between this answer and the value obtained in **part a.** (1 mark)

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Section F: [1.1 – 1.5] – Overall (VCAA Qs) (63 Marks)

Question 68 (1 mark)

Inspired from VCAA Chemistry Exam 2022
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2022/2022chem-w.pdf

A fuel undergoes combustion to heat water.

Which of the following descriptions of the energy and enthalpy of combustion, ΔH, of the reaction is correct?

	Energy	ΔH
A.	Absorbed by the water	Negative
B.	Released by the water	Negative
C.	Absorbed by the water	Positive
D.	Released by the water	Positive

Question 69 (1 mark)

Inspired from VCAA Chemistry Exam 2023
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2023/2023chemistry-w.pdf

Consider the following statements about fossil fuels and biofuels.

I. The production of biofuels does not damage the environment.
II. Combustion of both biofuels and fossil fuels generates greenhouse gases.
III. Biofuels and fossil fuels are both renewable as they are produced from plants.

Which of the statements above is correct?

A. I only

B. II only

C. I and II only

D. I and III only

Space for Personal Notes

Question 70 (1 mark)

Inspired from VCAA Mathematics Exam 2013
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2013/2013chem-w.pdf

Which of the following alternatives lists only renewable energy resources?

A. Coal, diesel, ethanol

B. Coal, crude oil, uranium

C. Ethanol, methane, diesel

D. Crude oil, natural gas, ethanol

Question 71 (1 mark)

Inspired from VCAA Mathematics Exam 2023
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2023/NHT/2023chem-nht-w.pdf

Bioethanol is a fuel produced by:

A. Fermentation.

B. Anaerobic digestion.

C. Transesterification of fats.

D. A substitution reaction of ethene.

Space for Personal Notes

Question 72 (1 mark)

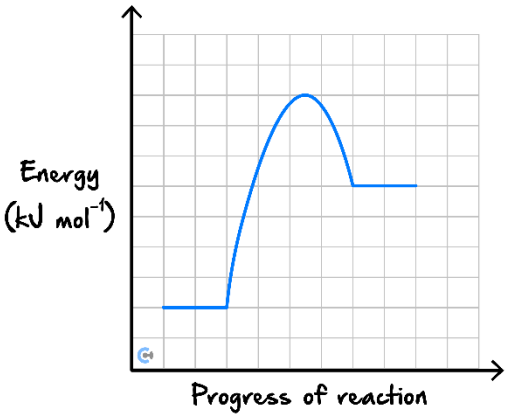
Inspired from VCAA Mathematics Exam 2022
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2022/2022chem-w.pdf

The graphs shown below are energy profiles for the following reaction.

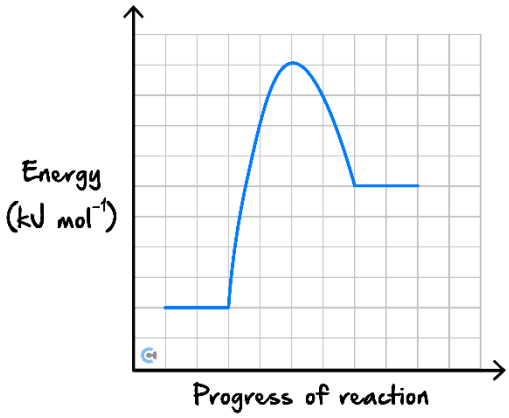
$$A + B \leftrightharpoons C \qquad \Delta H < 0$$

The graphs represent the forward reaction, with and without a catalyst, and the reverse reaction, with and without a catalyst. All graphs are drawn to the same scale.

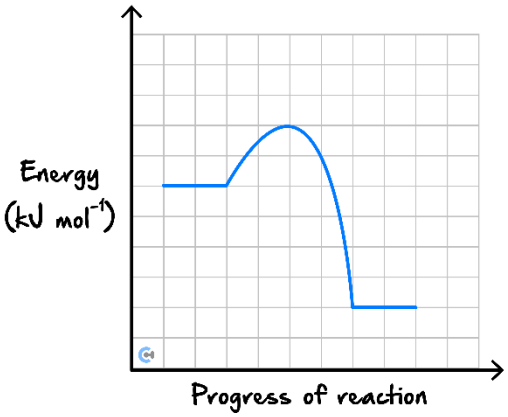
Graph 1



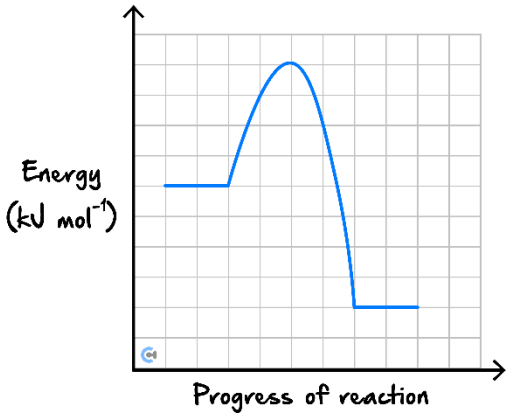
Graph 2



Graph 3



Graph 4



Which energy profile represents the reverse reaction without a catalyst?

A. Graph 1

B. Graph 2

C. Graph 3

D. Graph 4

Question 73 (1 mark)

Inspired from VCAA Mathematics Exam 2023
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2023/2023chemistry-w.pdf

Lignite is a type of brown coal. When lignite is completely combusted in a power station, 19.0 MJ/tonne of energy is released. The efficiency of the power station is 39%.

What mass of lignite is required to produce 42.0 MJ of usable energy in the power station?

A. 0.862 tonnes

B. 1.16 tonnes

C. 2.21 tonnes

D. 5.67 tonnes

Question 74 (1 mark)

Inspired from VCAA Chemistry Exam 2023
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2023/2023chemistry-w.pdf

Consider the following statements about coal seam gas and petroleum gas.

I. Coal seam gas and petroleum gas are both mixtures.
II. Coal seam gas and petroleum gas both combust to produce carbon dioxide.
III. Coal seam gas and petroleum gas are both fossil fuels.

Which of the above statements is correct?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Space for Personal Notes

Use the following information to answer the two questions that follow.

Inspired from VCAA Chemistry Exam 2023
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2023/2023chemistry-w.pdf

A student investigated the viscosity of several biofuels.

The flow rate of each biofuel through a narrow glass tube was measured. The results are presented in the tables below.

Table 1: Flow rate ($mL\ min^{-1}$) of biodiesels produced using sodium hydroxide, NaOH (aq), catalyst

		Alcohol used in biodiesel production with NaOH catalyst	
		Methanol	**Ethanol**
Oil used in biodiesel production	Sunflower oil	4.8	4.4
	Canola oil	5.1	4.7

Table 2: Flow rate ($mL\ min^{-1}$) of biodiesels produced using potassium hydroxide, KOH (aq), catalyst

		Alcohol used in biodiesel production with KOH catalyst	
		Methanol	**Ethanol**
Oil used in biodiesel production	Sunflower oil	4.9	4.4
	Canola oil	4.8	4.6

Question 75 (1 mark)

How many independent variables are there in this investigation?

A. 1

B. 3

C. 4

D. 6

Question 76 (1 mark)

Select the most valid conclusion that can be drawn from the student's results presented in Table 1 and Table 2.

A. Biodiesels made from sunflower oil have a higher viscosity than biodiesels made from canola oil.

B. Biodiesels made from methanol have a lower viscosity than biodiesels made from ethanol.

C. Biodiesels are unsuitable for use in cold climates because they have a higher viscosity than petrodiesel.

D. Biodiesels made using NaOH (aq) catalyst have a lower viscosity than biodiesels made using KOH (aq) catalyst.

Question 77 (1 mark)

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

A Year 12 Chemistry assignment requires students to quantitatively and qualitatively compare fossil fuels and biofuels.

Which one of the following investigations would be most appropriate for this comparison?

A. Use a bomb calorimeter to determine the heat of combustion for both fossil fuels and biofuels.

B. Interview car owners to determine what petrol price would make them consider using biofuels.

C. Produce biodiesel from vegetable oil and compare the viscosity of the biodiesel produced with that of a range of fossil fuels.

D. Find reliable information about the environmental impacts of producing fossil fuels and biofuels, and the amount of carbon dioxide produced per litre from the combustion of these fuels.

Space for Personal Notes

Use the following information to answer the two questions that follow.

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

Four identical vehicle models, 1, 2, 3 and 4, were tested for fuel efficiency using LPG, petrol (unleaded, 91 octane), E10 (petrol with 10% ethanol added) and petrodiesel. Carbon dioxide, CO_2, emissions per litre of fuel burnt were also determined. The following table summarises the results.

Vehicle Model	**Fuel**	**Fuel consumption ($L/100\ km$)**	**CO_2 produced ($g\ CO_2/L$ of fuel)**
1	LPG	19.7	1665
2	Petrol	14.5	2392
3	E10	14.2	2304
4	Petrodiesel	9.2	2640

Question 78 (1 mark)

Using the information in the table above, which one of the following statements about petrodiesel is correct?

A. It has the highest energy content.

B. It has the poorest fuel efficiency.

C. It is a renewable energy source.

D. It has the lowest CO_2 emissions when burnt.

Question 79 (1 mark)

The use of which vehicle has the smallest impact on the environment, in terms of the grams of CO_2 produced per 100 km?

A. Vehicle Model 1

B. Vehicle Model 2

C. Vehicle Model 3

D. Vehicle Model 4

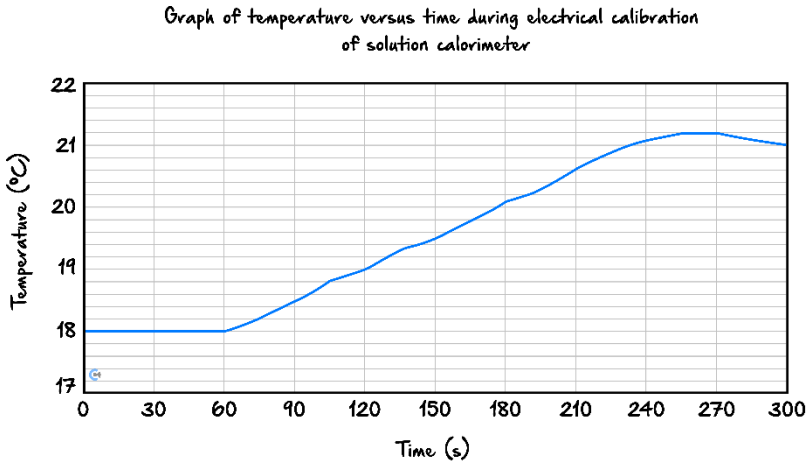
Space for Personal Notes

Use the following information to answer the two questions that follow.

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

A solution calorimeter containing 350 mL of water was set up. The calorimeter was calibrated electrically and the graph of the results is shown below.

Graph of temperature versus time during electrical calibration of solution calorimeter



The calorimeter was calibrated using a current of 2.7 A, starting at 60 s. The current was applied for 180 s and the applied voltage was 5.4 V.

Question 80 (1 mark)

What is the calibration factor for this calorimeter?

A. 125 $J\ °C^{-1}$

B. 820 $J\ °C^{-1}$

C. 847 $J\ °C^{-1}$

D. 875 $J\ °C^{-1}$

Question 81 (1 mark)

The calibration factor of a bomb calorimeter was determined by connecting the calorimeter to a power supply. The calibration was done using 100 mL of water, 6.5 V and a current of 3.6 A for 4.0 minutes. The temperature of the water increased by 0.48℃ during the calibration.

4.20 g of sucrose underwent complete combustion in the bomb calorimeter. The temperature of the 100 mL of water increased from 19.6℃ to 25.8℃.

$$M(C_{12}H_{22}O_{11}) = 342\ g\ mol^{-1}$$

The experimental heat of combustion of pure sucrose, in joules per gram, is:

A. 5.9×10^{6}

B. 7.3×10^{4}

C. 1.7×10^{4}

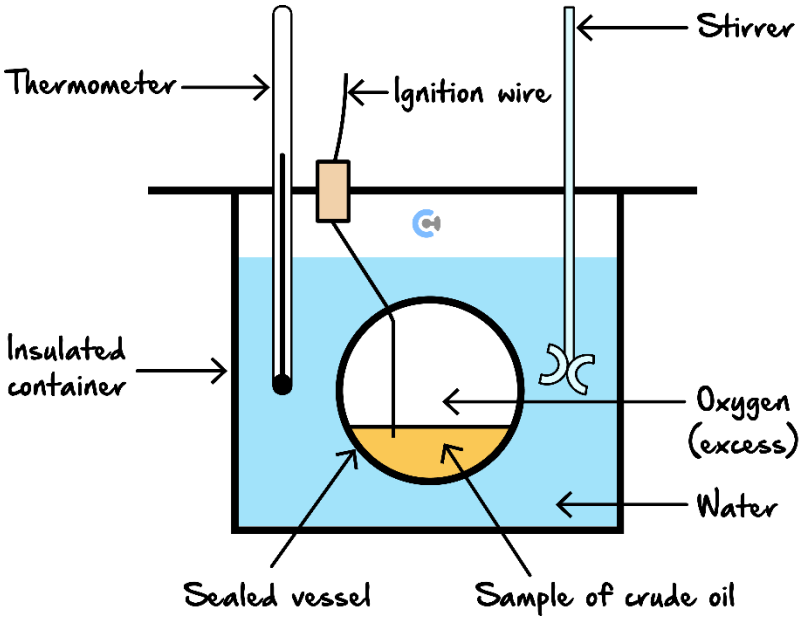
D. 1.2×10^{4}

Space for Personal Notes

Question 82 (1 mark)

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

The heat of combustion of a sample of crude oil is to be determined using a bomb calorimeter. All of the students in a class are given the same method to follow. The apparatus used by the students is shown below.



For this experiment, the students could maximise:

A. Precision by using a digital thermometer $\pm$ 0.2°C.

B. Validity by calculating the heat of combustion per mole.

C. Accuracy by taking samples from three different sources.

D. Uncertainty by having all students closely follow the same experimental procedure.

Space for Personal Notes

Question 83 (9 marks)

Inspired from VCAA Chemistry Exam 2023
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2023/2023chemistry-w.pdf#page=18

a. Propane is used as a fuel for barbeques.

i. Calculate the amount of energy released when 140.0 *g* of propane is completely combusted. (1 mark)

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

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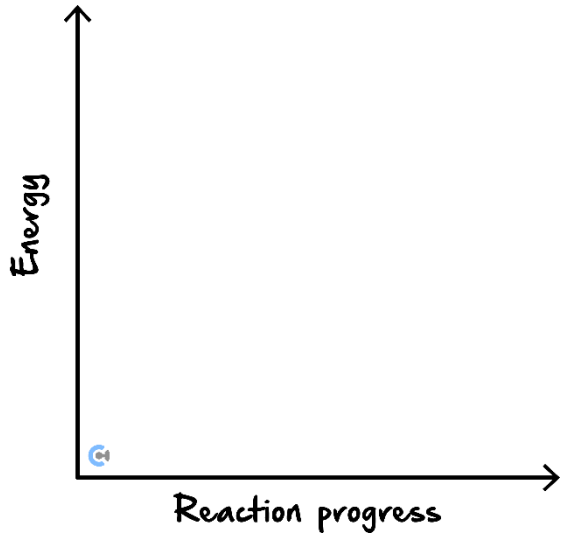
iii. Sketch the energy profile for the complete combustion of propane on the axes provided below. (1 mark)



iv. State how the energy profile for the **incomplete** combustion of propane would differ from the diagram you drew in **part a. iii.** Justify your answer. (2 marks)

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b. An equation for the complete combustion of ethanol, C_2H_5OH, is shown below.

$$C_2H_5OH\ (l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$$

96.0 g of ethanol completely combusts and the CO_2 produced is collected.

Calculate the volume of a tank required to store the captured CO_2 at 25.0℃ and 100.0 kPa. (3 marks)

Space for Personal Notes

Question 84 (10 marks)

Inspired from VCAA Chemistry Exam 2012
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2012/2012chem2-w.pdf#page=20

Methanol, CH_3OH, undergoes combustion according to the equation:

$$2CH_3OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(g)$$

In an experiment to determine its suitability as a fuel, a sample of methanol underwent complete oxidation in a bomb calorimeter.

The calorimeter was first calibrated by passing a current through an electric heater placed in the water surrounding the reaction vessel. A potential of 5.25 Volts was applied for 3.00 minutes. The measured current was 1.50 Amperes and the temperature of the water and reaction vessel increased by 0.593℃.

a.

i. Determine the calibration constant, in $kJ\ ℃^{-1}$, for the calorimeter and its contents. (2 marks)

A student then used this calorimeter to determine the molar heat of the combustion of methanol.

0.934 g of methanol was placed in the reaction vessel and excess oxygen was added. An electric ignition heater provided the energy required to initiate the combustion reaction. On this occasion, the temperature of the water increased by 8.63°C.

ii. Use this experimental data to determine the value of ΔH for the combustion of methanol given by the following equation.

$$2CH_3OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(g)$$

Include appropriate units in your answer. (5 marks)

b. The value of ΔH, calculated using the enthalpy of combustion provided in the data book, is different from the value of ΔH calculated from the experimental data provided in **part a. ii.**

Provide a reason for this difference. (1 mark)

Methanol is suitable for use in a micro fuel cell that is used to power laptop computers and similar small electrical items. The methanol is oxidised to carbon dioxide and water. The half-equation for the anode reaction is:

$$CH_3OH(l) + H_2O(l) \rightarrow 6H^+(aq) + CO_2(g) + 6e^-$$

c.

i. Write a balanced half-equation for the cathode reaction. (1 mark)

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ii. A finely divided platinum/ruthenium catalyst is used in this cell.

Give a reason why it is important to have a catalyst that will significantly reduce the activation energy for the cell reaction. (1 mark)

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Space for Personal Notes

Question 85 (5 marks)

Inspired from VCAA Chemistry Exam 2022
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2022/2022chem-w.pdf#page=21

Researchers have identified pathways that will enable the production of the biofuel 2-methylpropan-1-ol from proteins. 2-methylpropan-1-ol can be used in petrol engines. 2-methylpropan-1-ol has a heat of combustion of 36.1 $kJ\ g^{-1}$.

a. Compare the energy content of octane and 2-methylpropan-1-ol. Explain the difference. (2 marks)

b. A small fuel burner containing 2.36 g of 2-methylpropan-1-ol was placed directly underneath a beaker containing 500.0 g of water at standard laboratory conditions (SLC).

Calculate the maximum temperature that the water could reach if the contents of the fuel burner underwent complete combustion. (3 marks)

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Question 86 (6 marks)

Inspired from VCAA Chemistry Exam 2022
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2022/2022chem-w.pdf

Corn makes up a large proportion of people's diet in some parts of the world.

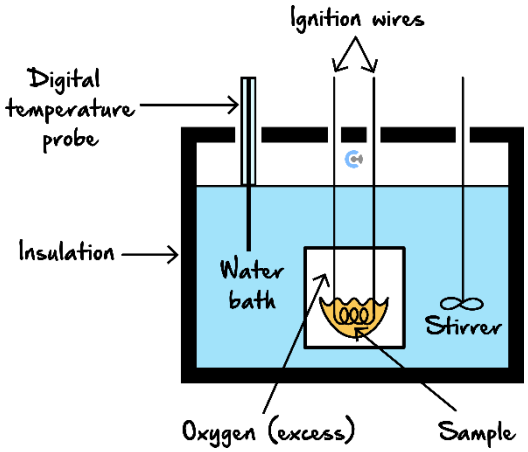
Air-popped popcorn is made from whole corn kernels. The nutrition content of a particular type of air-popped popcorn is provided in Table 1.

Table 1

	Average Quantity per 100 *g*
Protein	10.7 *g*
Fat	5.0 *g*
Carbohydrates	78.7 *g*

a. Using the information provided in Table 1, calculate the energy content of air-popped popcorn in kilojoules per gram. (2 marks)

The energy content of food can be determined experimentally using a bomb calorimeter similar to the one shown in the diagram below.



A 1.50 g sample of air-popped popcorn is placed in the bomb calorimeter. The initial temperature of the water is 22.2℃ and the final temperature is 25.7℃. Assume that the air-popped popcorn is fully combusted. The calibration factor for the bomb calorimeter is 6.54 kJ $℃^{-1}$.

b. Using the calibration factor provided, calculate the energy released by the air-popped popcorn in kilojoules per gram. (2 marks)

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c. Assume that the calorimeter was accurately calibrated so that heat loss from the calorimeter was accounted for in the calibration factor.

State **two** factors that may contribute to a difference in the energy content that was calculated using the methods in **part a.** and **part b**. (2 marks)

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Question 87 (6 marks)

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

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 carbon monoxide, CO. (1 mark)

b. 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℃ to 32.3℃.

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

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

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Question 88 (8 marks)

Inspired from VCAA Chemistry Exam 2011
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2011chem2-w.pdf#page=14

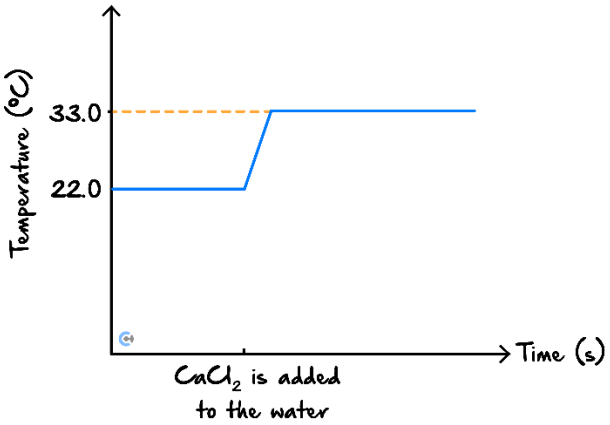
A solution calorimeter was calibrated by passing an electric current through the heating coil at a potential difference of 5.10 volts. This caused the water in the calorimeter to increase in temperature by 9.50℃. The calibration factor for this calorimeter was previously determined to be 0.354 $kJ\ ℃^{-1}$.

a. Use the calibration factor to determine the electrical charge, in coulombs, that passed through the heating coil. (2 marks)

This calorimeter is then used to determine the enthalpy change for the dissolution of one mol of anhydrous calcium chloride, $CaCl_2$, in water.

$$CaCl_2(s) \rightarrow CaCl_2(aq)$$

6.038 g of solid anhydrous calcium chloride, $CaCl_2$, was added to the water. The mixture was stirred until all the solids had dissolved. The temperature was monitored before and after the addition of the calcium chloride. The results are shown in the graph below.



b.

i. Is this reaction exothermic or endothermic? Explain your answer. (2 marks)

ii. Use the calibration factor to calculate the enthalpy change for the dissolution of 1.00 mol of $CaCl_2(s)$. The molar mass of $CaCl_2 = 111.1\ g\ mol^{-1}$. (4 marks)

Question 89 (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: 'Carbon NeutralEarth, <www.carbonneutralearth.com/biofuels.php>; 2Sejersgård Fanø, quoted in Erin Voegele, 'EU reaches deal on REDII, sets new goals for renewables', Biodiesel Magazine, 15 June 2018, <www.biodieselmagazine.com>; 3 & 4John DeCicco, 'Biofuels turn out to be a climate mistake - here's why', The Conversation, 5 October 2016, <http://theconversation.com/au>; Andrew Steer and Craig Hanson, 'Biofuels are not a green alternative to fossil fuels', The Guardian, 30 January 2015, www.theguardian.com/au

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

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