This worksheet enables practise on the following dot points

- Experimental errors
- Precision
- Accuracy
- Validity
- Repeatability
- Resolution of data
- Introduction to calorimetry *and how (ΔT) is directly related to ΔH, energy released or absorbed by the reaction.*
- Thermochemical equations and calculations
- Volume to volume stoichiometry (SLC)
- Temperature vs time graphs.

Molar heat of combustion of a fuel.

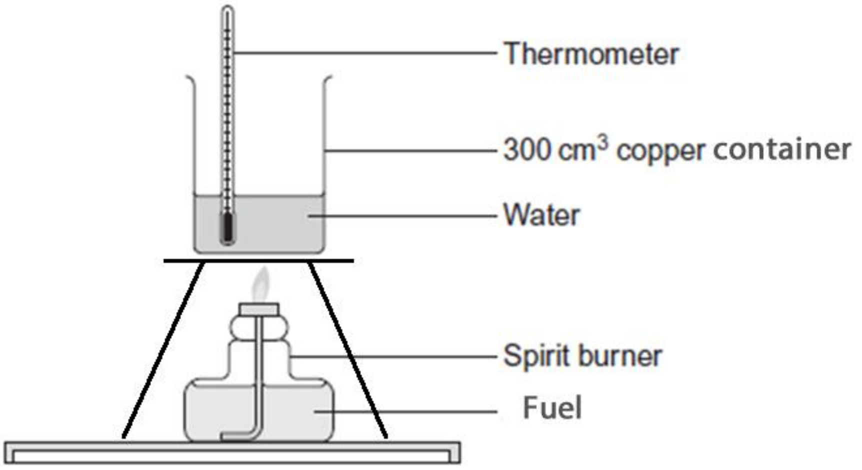

Figure 1 – A setup to determine the heat of combustion of an unknown biodiesel fuel.

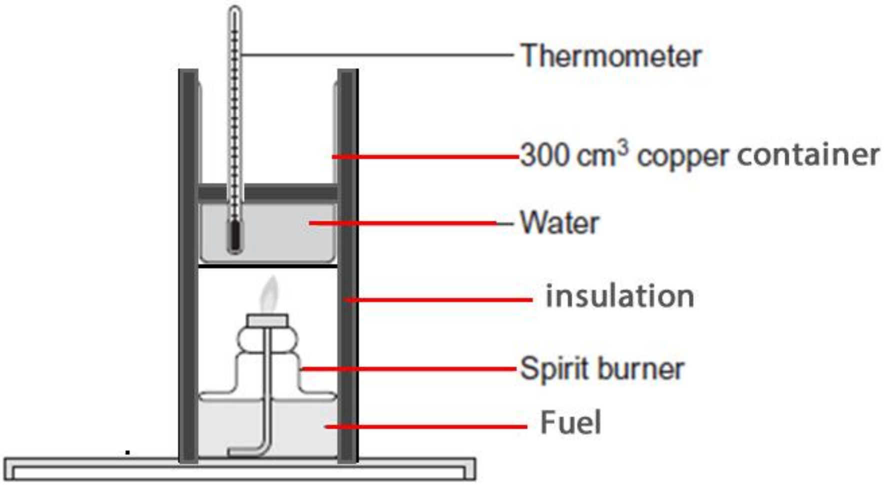

Figure 2 – A setup, with insulation, designed to determine the heat of combustion an unknown biodiesel.

Shown above are the experimental setups of two individual groups assigned the task of determining the heat of combustion in kJ/g of an unknown biodiesel. The table below shows the results of three groups. The mass of biodiesel for each group at each trial is also give in the table below.

Trial	Group 1 Using setup 1		Group 2 Using setup 2		Group 3 Using setup 2	
	ΔT (°C)	Mass of biodiesel (g)	ΔT (°C)	Mass of biodiesel (g)	ΔT (°C)	Mass of biodiesel (g)
1	33.5	3.0	25.5	3.00	38.9	3.0
2	41.4	3.0	24.6	3.00	38.6	3.0
3	35.6	3.0	25.4	3.00	37.8	3.0
4	29.8	3.0	25.2	3.00	37.9	3.0
5	30.2	3.0	24.9	3.00	37.7	3.0

Using the information presented above and given that the literature value for the heat of combustion of the biodiesel is 7130 J/g, answer the questions below.

1. Given the volume of water used was consistently 150 mL for each trial, calculate the average heat of combustion for each group. Assume density of water is 1.00 g/mL. Show all calculations and give each answer to the right number of significant figures.

   Group 1

   3 marks

   Group 2

   3 marks

   Group 3

   3 marks

2. Using the information from question 1, above, complete the table below to describe each group's data . Circle two appropriate responses.

Group	Accuracy	Validity	Precision
1	High accuracy Low accuracy	High validity Low validity	High precision Low precision
2	High accuracy Low accuracy	High validity Low validity	High precision Low precision
3	High accuracy Low accuracy	High validity Low validity	High precision Low precision

3. Analyse the data of each group and suggest a type of error the may be present. Provide one example of this type of error.

Group 1

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____ 2 marks

Group 2

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____ 2 marks

Group 3

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____ 2 marks

4. What is the resolution of the electronic scale used by each group?

Group 1 ____ 1 mark

Group 2 ____ 1 mark

Group 3 ____ 1 mark

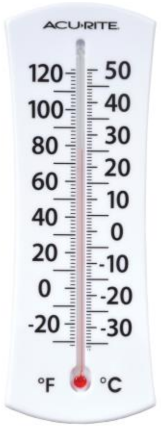

Figure 3. Thermometer used for temperature readings by all groups.

5. Consider the thermometer shown in fig. 3.
   a. Determine the resolution of this instrument.

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   ____ 1 mark

   b. With reference to the temperature readings from group 1, describe the difference between the terms ***precision*** and ***resolution***.

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   ____ 3 marks

6. Name one limitation of the setup shown in figure 2, above and state how this limitation will impact the final result.

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   ____ 2 marks

7. A reaction is represented by the equation shown below.

$$A(aq) + 2B(aq) \rightarrow AB_2(aq)$$

50.0 mL of 0.500 M A solution is mixed with 50.0 mL of a 1.00 M B solution in a solution calorimeter. The temperature of the water was measured over time and recorded in the graph in fig 1.

a.

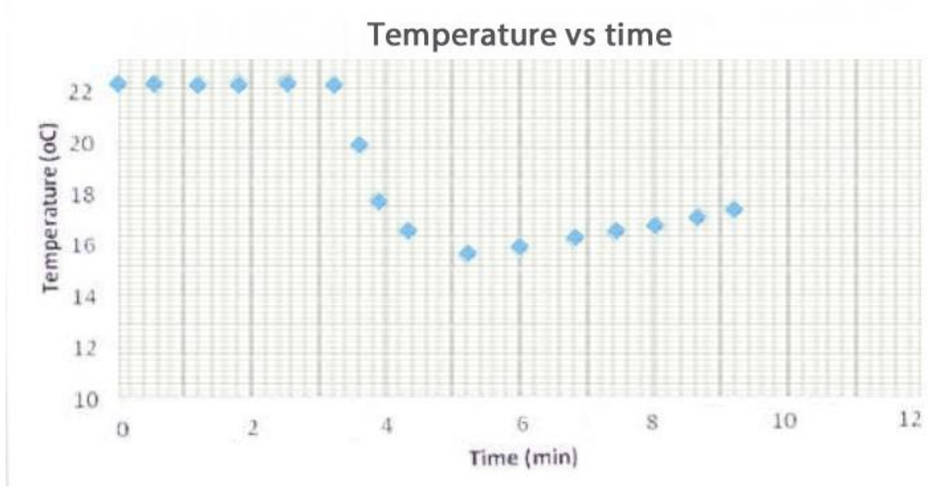

Figure 1 – temperature vs time graph

Using the graph in fig 1, calculate the change in temperature(ΔT) of the water in the beaker.

1 mark

b. Indicate if energy is absorbed or released by the reaction and calculate the amount of heat energy, in kJ, involved.

2 marks

c. What is assumed in calculating the amount of energy in b. above? 1 mark

d. Calculate the ΔH of the reaction below.

$$A(aq) + 2B(aq) \rightarrow AB_2(aq) \quad \Delta H = \_\_\_\_\_\_\_\_\_\_$$

2 marks

8. A bomb calorimeter is an instrument designed to measure the heat of combustion of different substances as shown in fig 2. Energy is measured indirectly by measuring the change in temperature of a given mass of water when fuel is burnt in the combustion chamber of the calorimeter.
A mass of 8.44×10^{-2} grams of liquid pentane was placed in the combustion chamber and ignited. The temperature of the 150.0 grams of water was then recorded at regular intervals and plotted on the graph shown in fig 3.

* bomb calorimetry is not covered in the 2024-2027 study design but the principles are similar to solution calorimetry .

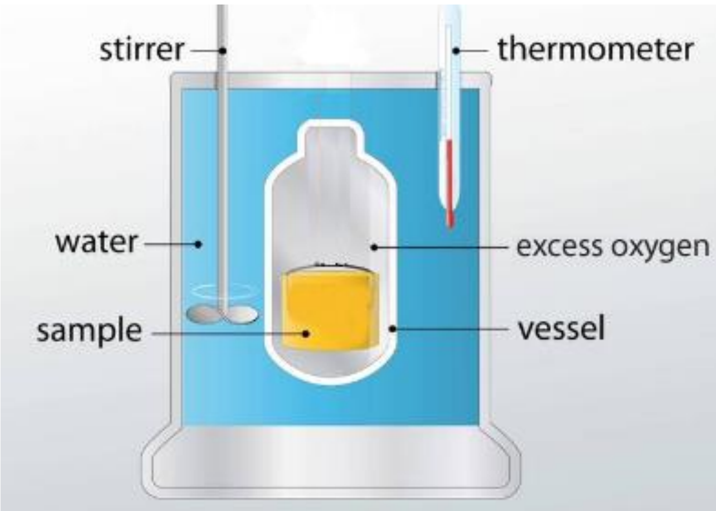

Figure 2 – A bomb calorimeter

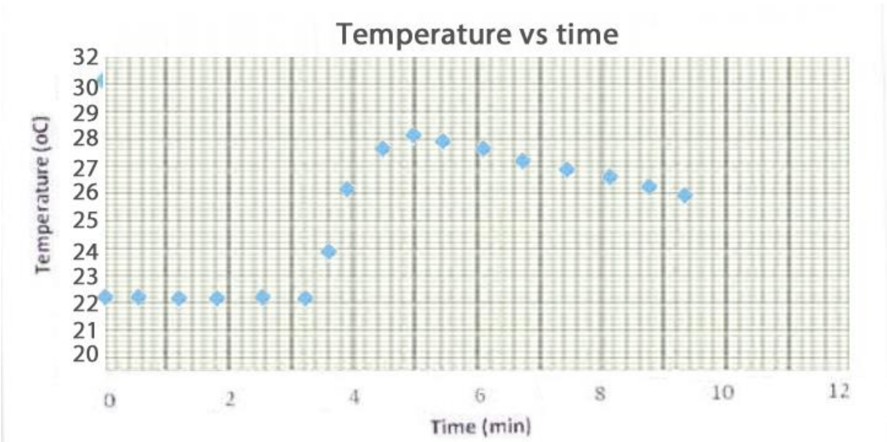

Figure 3 – temperature vs time graph for the combustion of pentane

a. Using the graph in fig 3 obtain the temperature change (ΔT) of the water. 1 mark

b. Give the balanced chemical equation for the complete combustion of pentane at SLC.

____ 2 marks

c. Calculate the ΔH for the equation given as the answer to question b. above. 4 marks

d. One experimenter accidentally placed 180 grams of water instead of 150 grams in the bomb calorimeter.

i. How does this impact the calculated ΔH for the reaction? Circle the correct response below. 1 mark

No change Gives a higher ΔH Gives a lower ΔH

ii. What type of error is this?

____ 1 mark

e. The analogue thermometer used to obtain the temperature readings is shown in fig 4.

i. What is the resolution of this instrument.

________________________________ 1 mark

ii. If the initial temperature of the water was recorded using a digital thermometer to 22.65 ^oC what would be the reading that should be recorded using the analogue thermometer shown in fig 4?

____ 1 mark

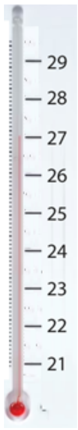

Figure 4

f. What is the volume of CO_2 produced if 400 litres of oxygen gas reacts with excess liquid pentane at SLC. 2 marks

9. Two organic acids, **Compound A** ($C_6H_{12}O_2$) and **Compound B** ($C_6H_{10}O_2$), undergo complete combustion, at SLC.

a. Write the balanced chemical equations for the combustion of both compounds. 3 marks

A. ____

B. ____

b. Consider the following bond energies, found in the data book in tables 10 and 11.

Bond Energies:

C-H: 414 kJ/mol
C-C: 346 kJ/mol
C=O: 804kJ/mol
C-O: 358kJ/mol
O-H: 463kJ/mol
O=O: 498kJ/mol

i. Using the balanced chemical equations provided in question a, above, and the bond energies provided, identify the acid with the highest molar heat of combustion and give an explanation to justify your answer.

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____ 3 marks

ii. Calculate the molar heat of combustion (ΔH), kJ/mol, of acid A . 2 marks

iii. Explain the difference in molar heat of combustion of both acids in terms of oxidation states.

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____ 2 marks