5.1 Energetics

Question Paper

Course	DP IB Chemistry
Section	5. Energetics / Thermochemistry
Topic	5.1 Energetics
Difficulty	Medium

Time allowed: 60

Score: /47

Percentage: /100

Question 1a

a) The reaction between solid ammonium nitrate and water is one which is often conducted in school laboratories.

i) Describe how the heat energy transferred (q) for the reaction between solid ammonium nitrate and water could be conducted in a school laboratory. Give the names of the apparatus that is needed and state the measurements that would be taken to find the enthalpy change of reaction.

ii) Discuss one major source of error in the experiment and suggest how that error would impact on the calculation of the enthalpy change (q).

[5 marks]

Question 1b

b) State the difference between *accuracy* and *precision* in experimental results.

[1 mark]

Question 1c

c) Write an equation for the reaction that occurs when ammonium nitrate is added to water.

[1 mark]

Question 1d

d) A student dissolves 3.5 g of ammonium nitrate in water and determines *q* to be 1828 J. Determine the enthalpy change for this reaction in kJ mol^{-1}.

[2 marks]

Question 2a

a) Methanol is an important industrial alcohol which is mostly used to create fuel, solvents, and antifreeze. A colorless liquid, it is volatile, flammable, and unlike ethanol, poisonous for human consumption.

The equation to show the enthalpy of combustion of methanol is:

$$CH_3OH\ (l) + 1½O_2\ (g) \rightarrow CO_2\ (g) + 2H_2O\ (g)$$

Use the equation and the information in **Table 1** below, to determine the theoretical enthalpy of combustion of methanol.

Table 1

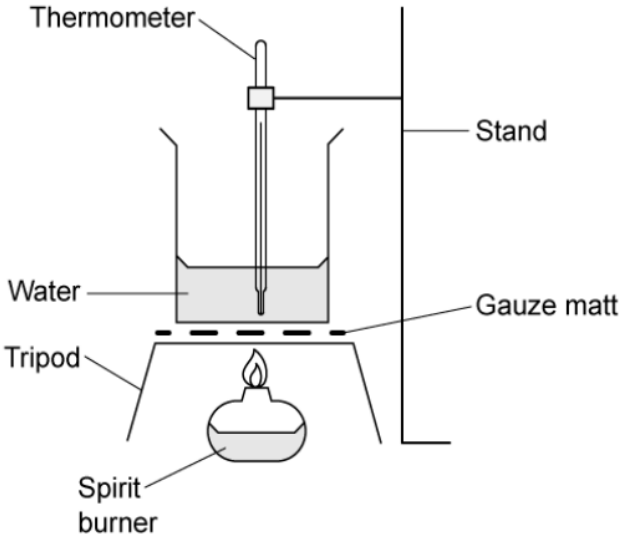
Bond	**C-O**	**O-H**	**C-H**	**O=O**	**C=O**
Mean bond enthalpy (kJmol^{-1})	358	463	414	498	804

[3 marks]

Question 2b

b) The enthalpy of combustion of an alcohol can be determined in a school laboratory using the following apparatus.

Figure 1



In an experiment, a spirit burner containing methanol was weighed and used to heat water in a beaker as shown above. The following results were obtained:

Starting mass of spirit burner and methanol / g	80.56
Final mass of spirit burner and methanol / g	80.03
Mass of water in the beaker / g	100.00
Initial water temperature / °C	21.5
Final water temperature / °C	32.1

i) Calculate the amount of methanol combusted in moles.

ii) Calculate the heat energy transferred to the water, q, in kJ. Take the specific heat capacity of water as 4.18 J g^{-1} K^{-1}.

iii) Find the enthalpy of combustion of methanol in kJ mol^{-1}.

[4 marks]

Question 2c

c) The accepted data book value for the enthalpy of combustion of methanol is -726 kJ mol^{-1}.

i) Suggest why the data value is different from the values calculated in part (a).

ii) Suggest why the data value is different from the values calculated in part (b).

[3 marks]

Question 2d

d) Suggest one improvement that could be made to the apparatus in part (b) that would give a more accurate result.

[1 mark]

Question 3a

a) A teacher instructs a class to complete a calorimetry practical, to calculate the enthalpy change that occurs when hydrochloric acid and sodium hydroxide react together.

Each student was given roughly 60 cm^3 of 0.35 mol dm^{-3} hydrochloric acid, roughly 60 cm^3 of 0.35 mol dm^{-3} sodium hydroxide, a polystyrene cup and access to all standard laboratory equipment.

Draw a diagram to demonstrate the practical set up that the students would need to use to determine the enthalpy change during this neutralisation reaction, and state the key measurements that the students would have to make.

[3 marks]

Question 3b

b) The students then completed the practical from part (a), using their own method and measurements that they had chosen.

One student found that when they reacted 35.0 cm^3 of the hydrochloric acid with 35.0 cm^3 of the sodium hydroxide, the temperature rose from 19.6 °C to 22.3 °C.

Determine the enthalpy change, ΔH, for this reaction in kJ mol^{-1}.
Assume that both solutions have a density of 1.00 g cm^{-3} and a specific heat capacity of 4.18 J g^{-1} K^{-1}.

[5 marks]

Question 3c

c) Explain why the value that you have calculated for the students' practical in part (b), might be different from the correct value given in a data book.

[1 mark]

Question 3d

d) State how the students' practical could be improved to allow the students to calculate a more accurate value which is closer to the correct value given in data books.

[1 mark]

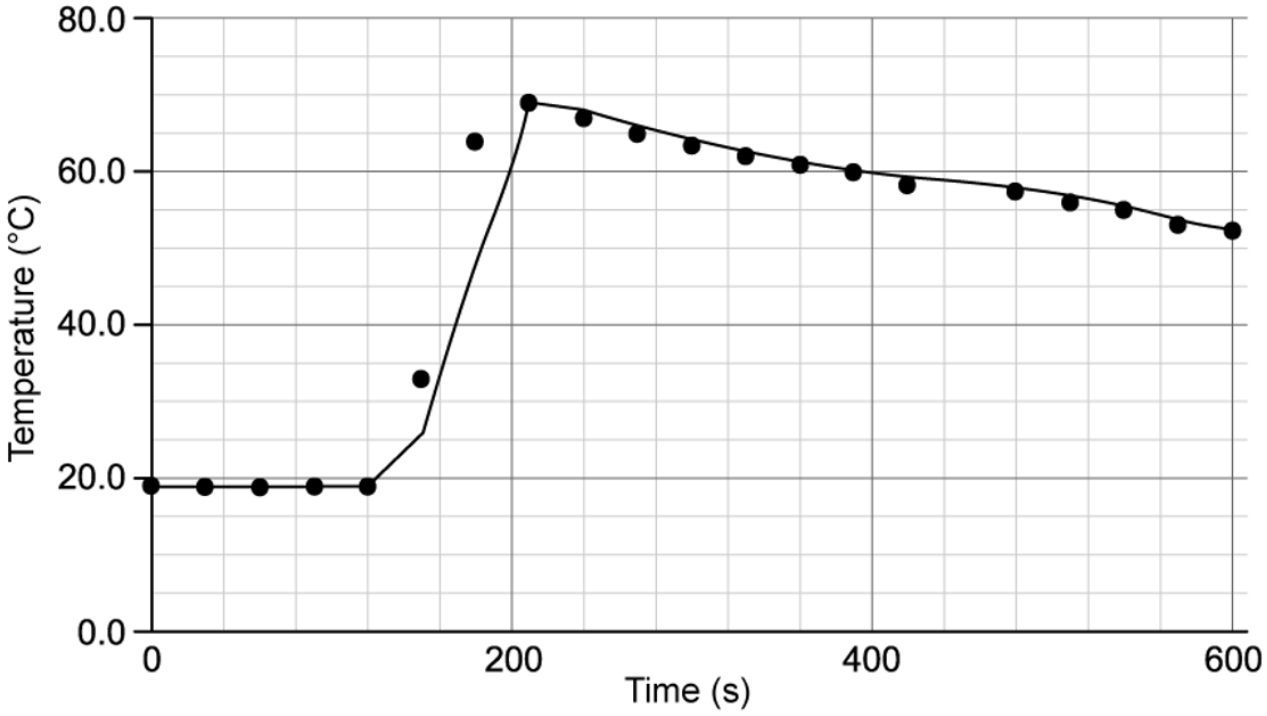
Question 4a

a) A group of students carried out a calorimetry experiment to determine the enthalpy change for the decomposition of hydrogen peroxide using manganese dioxide as a catalyst.

Each group added 1 g of manganese dioxide to 50.00 cm^3 of 2.00 mol dm^{-3} of hydrogen peroxide.

They recorded their data and drew a graph shown in **Figure 1**.

Figure 1



Use the graph to determine the temperature in the experiment.

[1 mark]

Question 4b

b) Using your answer to part (a) determine the enthalpy change, ΔH, for this reaction in kJ mol^{-1}.

Assume the solution has a density of 1.00 g cm^{-3} and a specific heat capacity of 4.18 J g^{-1} K^{-1} .

[4 marks]

Question 4c

c) Determine the enthalpy of reaction outlined in part (a) using the data in **Table 1**.

Table 1

	H_2O_2 (aq)	O_2 (g)	H_2O (l)
$\Delta H_f^{\ominus}$ (kJ mol^{-1})	-190	0	-285.8

[2 marks]

Question 4d

d) Draw the Lewis structure for hydrogen peroxide.

[1 mark]

Question 5a

a) Define the term *standard enthalpy of neutralisation* , $\Delta H^{\ominus}_{neut}$.

[3 marks]

Question 5b

b) A student carried out a neutralisation reaction and recorded the temperature change. 25.00 cm^3 of 1.0 mol dm^{-3} nitric acid, HNO_3 (aq) was neutralised by 50.00 cm^3 of 1.0 mol dm^{-3} of potassium hydroxide, KOH (aq).

The initial temperature of the potassium hydroxide was 20.5 °C and the reaction reached a maximum temperature of 24.5 °C.

Determine the enthalpy of neutralisation, $\Delta H^{\ominus}_{neut}$, assuming the solutions has a density of 1.00 g cm^{-3} and a specific heat capacity of 4.18 J g^{-1} K^{-1} . Give your answer in kJ mol^{-1} to **three** significant figures.

[4 marks]

Question 5c

c) Write an equation to demonstrate how nitric acid can behave as a Brønsted-Lowry acid when it reacts with water.

[1 mark]

Question 5d

d) The accepted theoretical value from the literature of this enthalpy change is -57 kJ mol^{-1}. Calculate the percentage error to **two** significant figures.

[1 mark]