Topic 5.1 Measuring Energy Changes

Past Exam Questions (Paper 2)

1. *[6 marks]*

In an experiment to measure the enthalpy change of combustion of ethanol, a student heated a copper calorimeter containing 100 cm^3 of water with a spirit lamp and collected the following data.

Initial temperature of water:	20.0 °C
Final temperature of water:	55.0 °C
Mass of ethanol burned:	1.78 g
Density of water:	1.00 g cm^{-3}

(i) Use the data to calculate the heat evolved when the ethanol was combusted.

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(ii) Calculate the enthalpy change of combustion per mole of ethanol.

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(iii) Suggest two reasons why the result is not the same as the value in the Data Booklet.

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2a. *[1 mark]*

Define the term *endothermic reaction*.

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2b. *[3 marks]*

Iron, used as the catalyst in the Haber process, has a specific heat capacity of $0.4490\ \mathrm{J\,g^{-1}K^{-1}}$. If 245.0 kJ of heat is supplied to 8.500 kg of iron, initially at a temperature of 15.25 °C, determine its final temperature in K.

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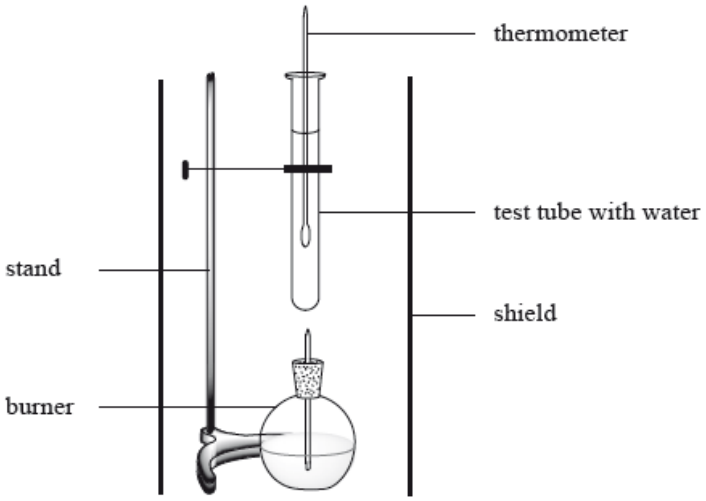
3a. *[2 marks]*

Methanol is made in large quantities as it is used in the production of polymers and in fuels. The enthalpy of combustion of methanol can be determined theoretically or experimentally.

$$\mathrm{CH_3OH(l)} + 1\frac{1}{2}\mathrm{O_2(g)} \rightarrow \mathrm{CO_2(g)} + 2\mathrm{H_2O(g)}$$

The enthalpy of combustion of methanol can also be determined experimentally in a school laboratory. A burner containing methanol was weighed and used to heat water in a test tube as illustrated below.



The following data were collected.

Initial mass of burner and methanol / g	80.557
Final mass of burner and methanol / g	80.034
Mass of water in test tube / g	20.000
Initial temperature of water / °C	21.5
Final temperature of water / °C	26.4

Calculate the amount, in mol, of methanol burned

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3b. *[3 marks]*

Calculate the heat absorbed, in kJ, by the water.

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3c. *[2 marks]*

Determine the enthalpy change, in $\mathrm{kJ\,mol^{-1}}$, for the combustion of 1 mole of methanol.

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4a. *[6 marks]*

The equation for the reaction between sodium hydroxide, NaOH, and nitric acid, $\mathrm{HNO_3}$, is shown below.

$$\mathrm{NaOH(aq) + HNO_3(aq) \rightarrow NaNO_3(aq) + H_2O(l)} \quad \Delta H = -57.6\ \mathrm{kJ\,mol^{-1}}$$

(i) Sketch and label an enthalpy level diagram for this reaction.

(ii) Deduce whether the reactants or the products are more energetically stable, stating your reasoning.

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(iii) Calculate the change in heat energy, in kJ, when $50.0\ \text{cm}^3$ of $2.50\ \text{mol dm}^{-3}$ sodium hydroxide solution is added to excess nitric acid.

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4b. *[3 marks]*

When 5.35 g ammonium chloride, $\text{NH}_4\text{Cl(s)}$, is added to $100.0\ \text{cm}^3$ of water, the temperature of the water decreases from 19.30 °C to 15.80 °C. Determine the enthalpy change, in kJ mol^{-1}, for the dissolving of ammonium chloride in water.

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5a. *[1 mark]*

In December 2010, researchers in Sweden announced the synthesis of N,N–dinitronitramide, $N(NO_2)_3$. They speculated that this compound, more commonly called trinitramide, may have significant potential as an environmentally friendly rocket fuel oxidant.

Methanol reacts with trinitramide to form nitrogen, carbon dioxide and water.

Deduce the coefficients required to balance the equation for this reaction.

$$\_\_\ N(NO_2)_3(g) + \_\_\ CH_3OH(l) \rightarrow \_\_\ N_2(g) + \_\_\ CO_2(g) + \_\_\ H_2O(l)$$

5b. *[3 marks]*

Methanol, CH_3OH can also be burnt as a fuel. Describe an experiment that would allow the molar enthalpy change of combustion to be calculated from the results.

5c. *[3 marks]*

Explain how the results of this experiment could be used to calculate the molar enthalpy change of combustion of methanol.

5d. *[2 marks]*

Predict, with an explanation, how the result obtained would compare with the value in Table 12 of the Data Booklet.

6. *[9 marks]*

Hydrochloric acid neutralizes sodium hydroxide, forming sodium chloride and water.

$$\mathrm{NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)} \quad \Delta H^{\ominus} = -57.9\ \mathrm{kJ\,mol^{-1}}$$

(i) Define the term *standard enthalpy change of reaction*, $\Delta H^{\ominus}$.

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(ii) Determine the amount of energy released, in kJ, when $50.0\ \mathrm{cm^3}$ of $1.00\ \mathrm{mol\,dm^{-3}}$ sodium hydroxide solution reacts with $50.0\ \mathrm{cm^3}$ of $1.00\ \mathrm{mol\,dm^{-3}}$ hydrochloric acid solution.

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(iii) In an experiment, 2.50 g of solid sodium hydroxide was dissolved in $50.0\ \mathrm{cm^3}$ of water. The temperature rose by 13.3 °C. Calculate the standard enthalpy change, in $\mathrm{kJ\,mol^{-1}}$, for dissolving one mole of solid sodium hydroxide in water.

$$\mathrm{NaOH(s) \rightarrow NaOH(aq)}$$

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(iv) Using relevant data from previous question parts, determine ΔH^{Θ}, in $\mathrm{kJ\,mol^{-1}}$, for the reaction of solid sodium hydroxide with hydrochloric acid.

$$\mathrm{NaOH(s) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)}$$