1. A vessel and its contents of total heat capacity 120 J K^{-1} were heated using a methane burner. Calculate the maximum theoretical temperature rise when 0.10 g of methane was completely burned. The standard enthalpy of combustion of methane is –890 kJ mol^{-1}.

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(4)

(Total 4 marks)

2. When cyclohexanol, $C_6H_{11}OH$, is completely burned in oxygen, the products are carbon dioxide and water.

Write an equation to represent the reaction that occurs during the measurement of the enthalpy change of combustion of cyclohexanol.

(Total 1 mark)

3. The table below includes some values of standard enthalpies of formation ($\Delta H_f^{\ominus}$).

Substance	$H_2O(l)$	LiOH(s)	Li(s)
$\Delta H_f^{\ominus}$ /kJ mol^{-1}	–286	–487	0

The standard enthalpy of solution of lithium hydroxide is given below.

$LiOH(s) \rightarrow Li^+(aq) + OH^-(aq)$ $\quad \Delta H^{\ominus} = 21$ kJ mol^{-1}

(a) State why the standard enthalpy of formation of lithium is quoted as zero.

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(1)

(b) Write an equation for the chemical reaction which represents the formation of lithium hydroxide from its elements, in which the enthalpy change is equal to its standard enthalpy of formation.

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(2)

(c) Write an equation, including state symbols, for the reaction of lithium with water in which lithium ions are formed.

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(2)

(d) Use the data given above to calculate a value for the enthalpy change for the reaction of lithium with water.

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(3)

(Total 8 marks)

4. (a) Explain the meaning of the terms *mean bond enthalpy* and *standard enthalpy of formation*.

Mean bond enthalpy .....

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Standard enthalpy of formation .....

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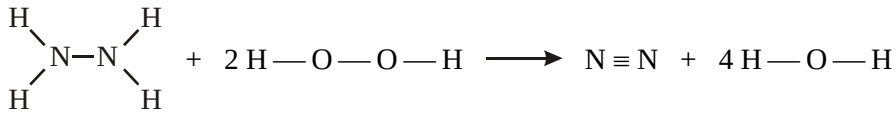
(5)

(b) Some mean bond enthalpies are given below.

Bond	N–H	N–N	N≡N	H–O	O–O
Mean bond enthalpy/kJ mol^{-1}	388	163	944	463	146

Use these data to calculate the enthalpy change for the following gas-phase reaction between hydrazine, N_2H_4, and hydrogen peroxide, H_2O_2



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(3)

(c) Some standard enthalpies of formation are given below.

	$N_2H_4(g)$	$H_2O_2(g)$	$H_2O(g)$
$\Delta H_f^{\ominus}$ /kJ mol^{-1}	+75	–133	–242

These data can be used to calculate the enthalpy change for the reaction in part (b).

$$N_2H_4(g) + 2H_2O_2(g) \rightarrow N_2(g) + 4H_2O(g)$$

(i) State the value of $\Delta H_f^{\ominus}$ for $N_2(g)$.

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(ii) Use the $\Delta H_f^{\ominus}$ values from the table to calculate the enthalpy change for this reaction.

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(4)

(d) Explain why the value obtained in part (b) is different from that obtained in part (c)(ii).

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(1)

(Total 13 marks)

5. Methanol, CH_3OH, is a convenient liquid fuel.

(a) An experiment was conducted to determine the enthalpy of combustion of liquid methanol. The energy obtained from burning 2.12 g of methanol was used to heat 150 g of water. The temperature of the water rose from 298 K to 362 K. (The specific heat capacity of water is 4.18 J K^{-1} g^{-1})

(i) Define the term *standard enthalpy of combustion*.

(ii) Use the data above to calculate a value for the enthalpy of combustion of one mole of liquid methanol.

(7)

(b) Methanol can be synthesised from methane and steam by a process that occurs in two stages.

Stage 1 $CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g)$ is $\Delta H^{\ominus} = +206 \text{ kJ mol}^{-1}$

Stage 2 $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$ $\Delta H^{\ominus} = -91 \text{ kJ mol}^{-1}$

The standard enthalpies of combustion of carbon monoxide and of hydrogen are -283 kJ mol^{-1} and -286 kJ mol^{-1}, respectively. Use these data and the enthalpy change for *Stage 2* to calculate a value for the standard enthalpy of combustion of gaseous methanol.

(3)

(Total 10 marks)