A level test 1_merged

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Medium Questions

1 (a) Propane reacts with chlorine to form chloropropane.

$C_3H_8(g) + Cl_2(g) \rightarrow C_3H_7Cl(g) + HCl(g)$

i) Use bond energies from Table 1.1 to calculate the enthalpy change for this reaction.

Table 1.1

Bond	**Bond Energy**
C-H	410
C-Cl	340
Cl-Cl	242
H-Cl	431

Include a sign in your answer.

enthalpy change = ... kJ mol^{-1}

[3]

ii) State the conditions needed for this reaction to occur.

[1]

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(4 marks)

(b) Using Fig. 1.1, construct a labelled reaction pathway diagram for the reaction in part **(a)** including the activation energy.

Fig. 1.1

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(3 marks)

(c) Ethane and chlorine will also react together under the same conditions.

State and explain the difference in enthalpy change for the two reactions

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(2 marks)

(d) Propane will react with bromine in a similar reaction to part **(a)**.

Suggest, with a reason, whether the sum of the bonds broken would be larger or smaller compared to the reaction between propane and chlorine.

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(2 marks)

2 (a) The apparatus shown in Fig. 2.1 can be used to determine the enthalpy of combustion of butan-1-ol, C_4H_9OH (M_r = 74.12 $gmol^{-1}$).

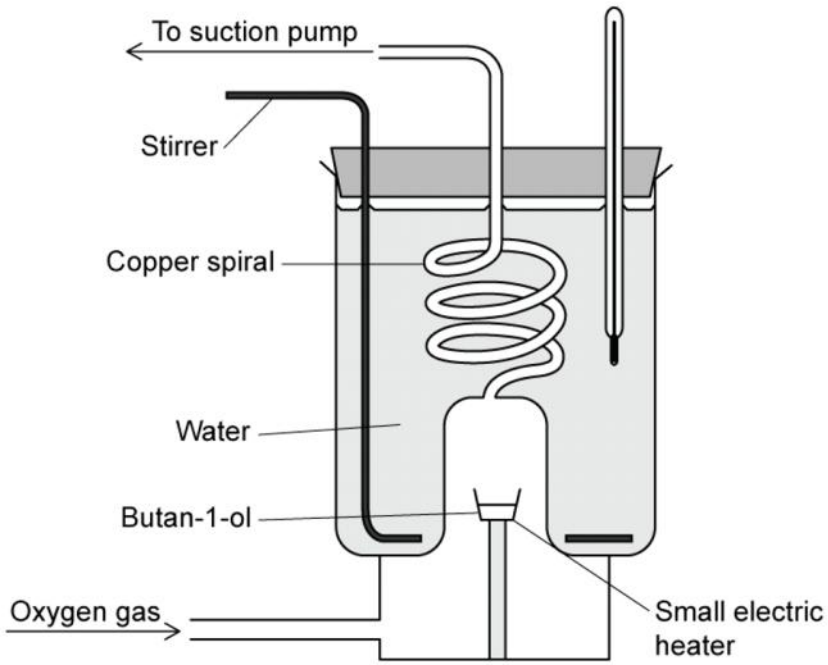

Fig. 2.1

i) Write an equation to represent the enthalpy of combustion of butan-1-ol.

[2]

ii) Suggest the purpose of the copper spiral and small electric heater in the apparatus.

[2]

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(4 marks)

(b) An experiment was carried out and the follow measurements were recorded in Table 2.1

Table 2.1

Mass of butan-1-ol / g	2.20 g	Initial temperature of water / °C	22.5
Volume of water / cm^3	875 cm^3	Final temperature of water / °C	25.0

(Specific heat capacity of water = 4.18 J $g^{-1}K^{-1}$)

Use the data to calculate the enthalpy of change, *q*, for the reaction. Give your answer to two significant figures.

q = ... kJ

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(2 marks)

(c) Determine the enthalpy of combustion of butan-1-ol using Table 2.1 and your answer to part **(b)**.

Give your answer to three significant figures.

ΔH = ... kJ mol^{-1}

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(3 marks)

3 (a) Two common oxides of nitrogen are nitrogen monoxide, NO, and nitrogen dioxide, NO_2.

i) Complete Table 3.1 to show the oxidation number of nitrogen in each compound.

Table 3.1

Compound	**NO**	**NO_2**
oxidation number of N		

[1]

ii) Write equations for the formation of NO_2 by:

- The reaction of N_2 with O_2
- The reaction of NO with O_2

[2]

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(1 mark)

(b) Molecules of NO_2 can be formed by the reaction between N_2 and O_2. The bond between the N and O atoms in NO_2 is a double covalent bond.

The enthalpy change of reaction for this reaction is +497 kJ mol^{-1}. Calculate the bond enthalpy, in kJ mol^{-1}, of the N=O bond. Use relevant data from Table 3.2.

Table 3.2

Bond	Bond energy / kJ mol^{-1}
N≡N	941
O=O	495

Bond enthalpy of the N=O bond = ... kJ mol^{-1} [2]

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(3 marks)

(c) The boiling points of carbon dioxide and nitrogen dioxide are -78.5 °C and 21 °C respectively.

Suggest a reason for the difference.

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(2 marks)

(d) Write an equation for the enthalpy of formation of nitrogen monoxide, NO.

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(1 mark)

4 (a) Propane gas is used widely as a fuel which can be be used in camping gas stoves. The enthalpy of combustion for propane is -2219.2 kJ mol^{-1}.

What is the minimum mass of fuel is needed to bring 150 cm^3 of water at 21 °C to its boiling point?

Show your working.

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(3 marks)

(b) Suggest why more propane may be required than calculated in part **(a)**.

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(1 mark)

(c) Using Fig. 5.1, construct a labelled reaction pathway diagram for the reaction in part **(a)** including the activation energy.

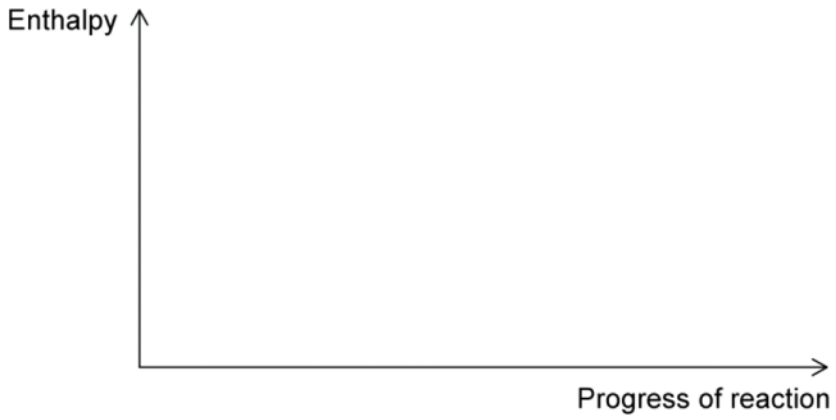

Fig. 5.1

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(3 marks)

Hard Questions

1 (a) The enthalpy change of solution for ammonium chloride can be measured using calorimetry. 12.04 g of ammonium chloride is dissolved in 125.0 cm^3 of water at 19.5 °C.

The enthalpy of solution of ammonium chloride is +15.1 kJ mol^{-1}. Determine the energy change, in J, when 12.04 g of ammonium chloride is dissolved in 125.0 cm^3 of water.

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(2 marks)

(b) Use your answer to part (a) to determine the change in temperature, in °C, when the ammonium chloride is dissolved.

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(1 mark)

(c) Use your answer to part (b) to determine the final temperature, in °C, of the solution during the reaction.

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(1 mark)

2 (a) Determine the enthalpy of hydrogenation of propene using the data in Table 2.1.

Table 2.1

Bond	**Bond enthalpy / kJ mol^{-1}**
H-H	435
C-H	413
C-C	347
C=C	619

Enthalpy of hydrogenation, ΔH_r = ... kJ mol^{-1}

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.....

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(3 marks)

(b) Use the data in Table 2.1 to suggest, with a reason, whether the polymerisation of propene is exothermic or endothermic

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(2 marks)

(c) Carbon, hydrogen and ethene each burn exothermically in an excess of air.

$C(s) + O_2(g) \rightarrow CO_2(g)$	$\Delta H^{\theta}_c = -393.7$ kJ mol^{-1}
$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$	$\Delta H^{\theta}_c = -285.9$ kJ mol^{-1}
$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$	$\Delta H^{\theta}_c = -1411.0$ kJ mol^{-1}

Use the data to calculate the standard enthalpy change of formation, ΔH^{θ}_f, in kJ mol^{-1}, of ethene at 298 K.

$$2C(s) + 2H_2(g) \rightarrow C_2H_4(g)$$

ΔH^{θ}_f = ... kJ mol^{-1}

.....

.....

(2 marks)

Hard Questions

1 In the gas phase, phosphorus pentachloride can be thermally decomposed into gaseous phosphorus trichloride and chlorine.

$$PCl_5 \rightarrow PCl_3 + Cl_2$$

The table below gives the relevant bond energies found in these compounds.

Bond	Bond energy / kJ mol^{-1}
P – Cl (in both chlorides)	328
Cl – Cl	241

What is the enthalpy change in the decomposition of the reaction?

A. – 415 kJ mol^{-1}

B. + 415 kJ mol^{-1}

C. + 95 kJ mol^{-1}

D. – 95 kJ mol^{-1}

(1 mark)

2 In a calorimetric experiment 2.50 g of a fuel is burnt in oxygen. 30 % of the energy released during the combustion is absorbed by 500 g of water, the temperature of which rises from 25 °C to 68 °C.

The specific heat capacity of water is 4.18 J g^{-1} K^{-1}.

What is the total energy released per gram of fuel burnt?

A. 25 284 J

B. 63 210 J

C. 119 827 J

D. 301 000 J

(1 mark)

3 Which equation correctly shows how the bond energy for the covalent bond Y-Z can be calculated by dividing ΔH by n?

A. n YZ (g) → n Y (g) + $\frac{n}{2}$ Z_2 (g)

B. Z (g) + Y Z_{n-1} (g) → YZ_n (g)

C. 2 YZ_n (g) → 2 YZ_{n-1} (g) + Y_2 (g)

D. YZ_n (g) → Y (g) + nZ (g)

(1 mark)

4 The diagram shows the skeletal formula of cyclobutane.

The enthalpy change of formation of cyclobutane is +75.1 kJ mol^{-1}, and the enthalpy change of atomisation of graphite is +712 kJ mol^{-1}.

The bond enthalpy of C–H is 390 kJ mol^{-1} and of H–H is 429 kJ mol^{-1}.

What is the average bond enthalpy of the C–C bond in cyclobutane, rounded to the nearest whole number?

A. 236 kJ mol^{-1}

B. 315 kJ mol^{-1}

C. 342 kJ mol^{-1}

D. 700 kJ mol^{-1}

(1 mark)

5 Some bond energy values are listed below.

Bond	Bond energy / kJ mol^{-1}
Br – Br	194
Cl – Cl	247
C – H	412
C – Cl	338

These bond energy values relate to the following four reactions:

W	$Br_2 \rightarrow 2Br$
X	$2Cl \rightarrow Cl_2$
Y	$CH_3 + Cl \rightarrow CH_3Cl$
Z	$CH_4 \rightarrow CH_3 + H$

What is the correct order of enthalpy changes of the above reactions from most negative to most positive?

A. Y → Z → W → X

B. Z → W → X → Y

C. Y → X → W → Z

D. X → Y → Z → W

(1 mark)