

Q1.Ethanol is an important fuel.

- (a) A dilute aqueous solution of ethanol can be produced by the fermentation of an aqueous solution of glucose.
It is claimed that the ethanol obtained from this solution is a carbon-neutral biofuel.

Write an equation for this fermentation reaction.

Give **two** other essential conditions for this reaction to produce a good yield of ethanol.

Name a process used to produce a much more concentrated solution of ethanol from a dilute aqueous solution.

State the meaning of the term **carbon-neutral** in the context of this biofuel.

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

(Extra space)
.....
.....
.....
.....

(5)

- (b) A student carried out a laboratory experiment to determine the enthalpy change when a sample of ethanol was burned. The heat produced was used to warm some water in a copper calorimeter. The student found that the temperature of 75.0 g of water increased by 5.50 °C when 2.40×10^{-3} mol of pure ethanol was burned in air.

Use the student's results to calculate a value, in kJ mol⁻¹, for the enthalpy change when one mole of ethanol is burned.

(The specific heat capacity of water is $4.18 \text{ J K}^{-1} \text{ g}^{-1}$)

Deduce **two** reasons why the student's value for the standard enthalpy of combustion of ethanol is different from a Data Book value of $-1279 \text{ kJ mol}^{-1}$.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Extra space).....

.....

.....

.....

.....

.....

(5)

(c) Mean bond enthalpies can be used to calculate enthalpies of reaction.

(i) Give the meaning of the term **mean bond enthalpy**.

.....

.....

.....

.....

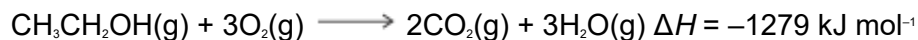
.....

(2)

(ii) Consider the mean bond enthalpy data in the following table.

	C—H	C—C	C—O	O=O	C=O	O—H
Mean bond enthalpy / kJ mol ⁻¹	412	348	360	to be calculated	805	463

Use the data in the table above and the equation shown to calculate a value for the bond enthalpy for the O=O double bond in an oxygen molecule.



.....

.....

.....

.....

.....

.....

.....

.....

.....

(3)
(Total 15 marks)

Q2. Ethanol is an important industrial compound.

- (a) Ethanol can be produced by the hydration of ethene.
The equation for the equilibrium that is established is



The operating conditions for the process are a temperature of 300 °C and a pressure of 7 MPa.

Under these conditions, the conversion of ethene into ethanol is 5%.

- (i) Identify the catalyst used in this process.
Deduce how an overall yield of 95% is achieved in this process without changing the operating conditions.

.....

.....

.....
.....

(2)

- (ii) Use your knowledge of equilibrium reactions to explain why a manufacturer might consider using an excess of steam in this process, under the same operating conditions.

.....
.....
.....
.....
.....
.....
.....

(3)

- (iii) At pressures higher than 7 MPa, some of the ethene reacts to form a solid with a relative molecular mass greater than 5000.

Deduce the identity of this solid.

Give **one** other reason for **not** operating this process at pressures higher than 7 MPa.

Do **not** include safety reasons.

.....
.....
.....

(2)

- (b) Write an equation for the reaction that has an enthalpy change that is the standard enthalpy of formation of ethanol.

.....

(2)

(c) When ethanol is used as a fuel, it undergoes combustion.

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

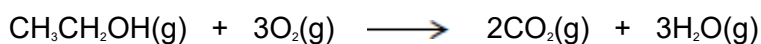
.....
.....
.....
.....
.....
.....
.....

(3)

(ii) Consider these bond enthalpy data.

	C-H	C-C	C-O	O=O	C=O	O-H
Bond enthalpy / kJ mol⁻¹	412	348	360	496	805	463

Use these data and the equation to calculate a value for the enthalpy of combustion of gaseous ethanol.



.....
.....
.....
.....
.....
.....
.....

(3)

(d) Gaseous ethanol can be used to convert hot copper(II) oxide into copper.

(i) Deduce the role of ethanol in this reaction.

.....

(1)

- (ii) Draw the structure of the organic compound with $M_r = 60$ that is produced in this reaction.

(1)

(Total 17 marks)

Q3. This question is about bond dissociation enthalpies and their use in the calculation of enthalpy changes.

- (a) Define *bond dissociation enthalpy* as applied to chlorine.

.....
.....
.....
.....
.....

(2)

- (b) Explain why the enthalpy of atomisation of chlorine is exactly half the bond dissociation enthalpy of chlorine.

.....
.....
.....

(1)

- (c) The bond dissociation enthalpy for chlorine is $+242 \text{ kJ mol}^{-1}$ and that for fluorine is $+158 \text{ kJ mol}^{-1}$. The standard enthalpy of formation of $\text{ClF}(\text{g})$ is -56 kJ mol^{-1} .

- (i) Write an equation, including state symbols, for the reaction that has an enthalpy change equal to the standard enthalpy of formation of gaseous ClF

.....

(1)

(ii) Calculate a value for the bond enthalpy of the Cl – F bond.

.....
.....
.....
.....
.....
.....

(2)

(iii) Calculate the enthalpy of formation of gaseous chlorine trifluoride, ClF₃(g). Use the bond enthalpy value that you obtained in part (c)(ii).

(If you have been unable to obtain an answer to part (c)(ii), you may assume that the Cl – F bond enthalpy is +223 kJ mol⁻¹. This is **not** the correct value.)

.....
.....
.....
.....
.....
.....

(3)

(iv) Explain why the enthalpy of formation of ClF₃(g) that you calculated in part (c)(iii) is likely to be different from a data book value.

.....
.....

(1)

(d) Suggest why a value for the Na – Cl bond enthalpy is **not** found in any data book.

.....
.....

Q4.Hydrazine (N_2H_4) decomposes in an exothermic reaction. Hydrazine also reacts exothermically with hydrogen peroxide when used as a rocket fuel.

- (a) Write an equation for the decomposition of hydrazine into ammonia and nitrogen only.

.....

(1)

- (b) State the meaning of the term *mean bond enthalpy*.

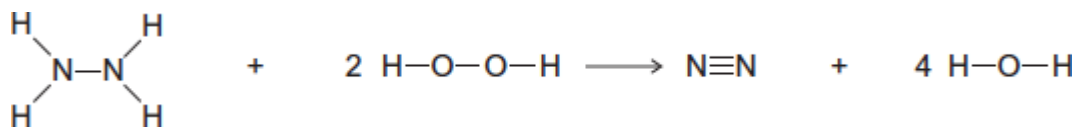
.....
.....
.....
.....
.....

(2)

- (c) Some mean bond enthalpies are given in the table.

	N-H	N-N	$N\equiv N$	O-H	O-O
Mean bond enthalpy / kJ mol^{-1}	388	163	944	463	146

Use these data to calculate the enthalpy change for the gas-phase reaction between hydrazine and hydrogen peroxide.



.....
.....

.....

.....

.....

.....

(3)
(Total 6 marks)