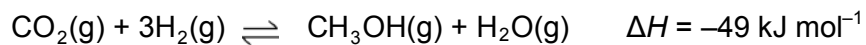


- 4 Many chemical processes release waste products into the atmosphere. Scientists are developing new solid catalysts to convert more efficiently these emissions into useful products, such as fuels. One example is a catalyst to convert these emissions into methanol. The catalyst is thought to work by breaking a H–H bond.

An equation for this formation of methanol is given below.



Some mean bond enthalpies are shown in **Table 2**.

Table 2

Bond	C=O	C–H	C–O	O–H
Mean bond enthalpy / kJ mol^{-1}	743	412	360	463

- 0 4 . 1 Use the enthalpy change for the reaction and data from **Table 2** to calculate a value for the H–H bond enthalpy.

[3 marks]

H–H bond enthalpy = _____ kJ mol^{-1}

- 0 4 . 2 A data book value for the H–H bond enthalpy is 436 kJ mol^{-1} .

Suggest **one** reason why this value is different from your answer to Question 4.1.

[1 mark]

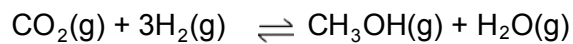
0 4 . **3** Suggest **one** environmental advantage of manufacturing methanol fuel by this reaction. **[1 mark]**

0 4 . **4** Use Le Chatelier's principle to justify why the reaction is carried out at a high pressure rather than at atmospheric pressure. **[3 marks]**

0 4 . **5** Suggest why the catalyst used in this process may become less efficient if the carbon dioxide and hydrogen contain impurities. **[1 mark]**

Question 4 continues on the next page

- 0 4** . **6** In a laboratory experiment to investigate the reaction shown in the equation below, 1.0 mol of carbon dioxide and 3.0 mol of hydrogen were sealed into a container. After the mixture had reached equilibrium, at a pressure of 500 kPa, the yield of methanol was 0.86 mol.



Calculate a value for K_p
Give your answer to the appropriate number of significant figures.
Give units with your answer.

[7 marks]

$K_p =$ _____ $\text{Units} =$ _____