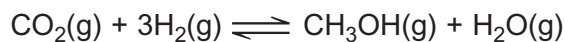## Section B

Answer **all** questions in the spaces provided.

6 Methanol can be regarded as a carbon-neutral fuel because it can be synthesised from carbon dioxide as shown in the equation below.

$$CO_2(g) + 3H_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g)$$

Standard enthalpy of formation and standard entropy data for the starting materials and products are shown in the following table.

	$CO_2(g)$	$H_2(g)$	$CH_3OH(g)$	$H_2O(g)$
$\Delta H_f^{\ominus}$/ kJ mol^{-1}	−394	0	−201	−242
$S^{\ominus}$/ J K^{-1} mol^{-1}	214	131	238	189

6 (a) Calculate the standard enthalpy change for this reaction.

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(3 marks)

6 (b) Calculate the standard entropy change for this reaction.

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(3 marks)

6 (c) Use your answers to parts **(a)** and **(b)** to explain why this reaction is **not** feasible at high temperatures.

Calculate the temperature at which the reaction becomes feasible.

Suggest why the industrial process is carried out at a higher temperature than you have calculated.

(If you have been unable to calculate values for ΔH and ΔS you may assume that they are $-61\,kJ\,mol^{-1}$ and $-205\,J\,K^{-1}\,mol^{-1}$ respectively. These are **not** the correct values.)

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(6 marks)

(Extra space) ....

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Question 6 continues on the next page

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6 (d) Write an equation for the complete combustion of methanol. Use your equation to explain why the combustion reaction in the gas phase is feasible at all temperatures.

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(4 marks)

(Extra space) ....

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6 (e) Give **one** reason why methanol, synthesised from carbon dioxide and hydrogen, may **not** be a carbon-neutral fuel.

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(1 mark)

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