

Name of the Student: _____

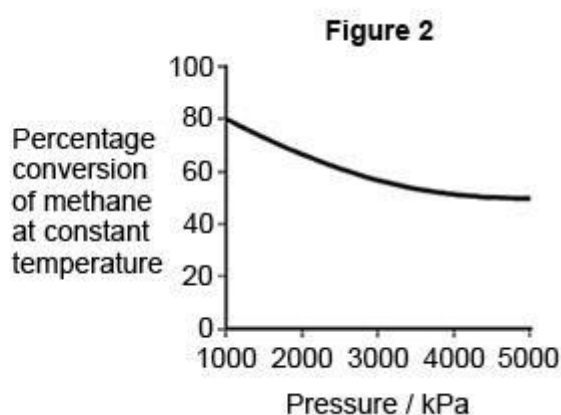
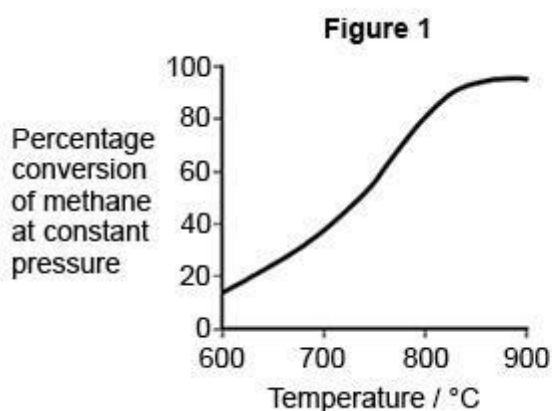
Max. Marks : 26 Marks

Time : 26 Minutes

Q1.

There are several stages in the industrial production of methanol from methane.

- (a) The first stage involves a gaseous equilibrium between the reactants (methane and steam), and some gaseous products. **Figures 1** and **2** show the percentage conversion of methane into the gaseous products under different conditions at equilibrium.

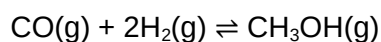


Deduce the optimum conditions for the industrial conversion of methane and steam into the gaseous products.

Explain your deductions.

(6)

- (b) The equation shows the final stage in the production of methanol.



20.1 mol of carbon monoxide and 24.2 mol of hydrogen were placed in a sealed container. An equilibrium was established at 600 K. The equilibrium mixture contained 2.16 mol of methanol.

Calculate the amount, in moles, of carbon monoxide and of hydrogen in the equilibrium mixture.

Amount of carbon monoxide = _____ mol

Amount of hydrogen = _____ mol

(2)

- (c) A different mixture of carbon monoxide and hydrogen was allowed to reach equilibrium at 600 K

At equilibrium, the mixture contained 2.76 mol of carbon monoxide, 4.51 mol of hydrogen and 0.360 mol of methanol. The total pressure was 630 kPa

Calculate a value for the equilibrium constant, K_p , for this reaction at 600 K and state its units.

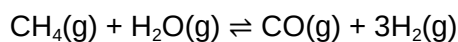
Value of K_p _____ Units _____

(6)

(Total 14 marks)

Q2.

Hydrogen can be manufactured by the reaction of methane with steam. An equilibrium is established as shown by the equation.



- (a) Use Le Chatelier's principle to predict the effect on the equilibrium yield of hydrogen if the overall pressure is increased.
Explain your answer.

Effect on yield _____

Explanation _____

(3)

- (b) Explain why the equilibrium yield of hydrogen is unchanged if a catalyst is used in the reaction.

(2)

- (c) The table shows the standard enthalpy of formation and the standard entropy for each substance in this equilibrium reaction.

	$\text{CH}_4(\text{g})$	$\text{H}_2\text{O}(\text{g})$	$\text{CO}(\text{g})$	$\text{H}_2(\text{g})$
$\Delta_f H^\ominus / \text{kJ mol}^{-1}$	-75	-242	-111	0
$S^\ominus / \text{J K}^{-1} \text{mol}^{-1}$	186	189	198	131

Use data from the table to calculate the standard enthalpy change for this equilibrium reaction.

Standard enthalpy change _____ kJ mol^{-1}

(2)

Use your answer from part (c) and the entropy data from the table above to calculate the minimum temperature, in $^\circ\text{C}$, needed for this reaction to be feasible.

Give your answer to the appropriate number of significant figures.

(If you did not complete part (c) you should assume a value of 120 kJ mol^{-1} for the standard enthalpy change. This is **not** the correct value).

Minimum temperature _____ $^\circ\text{C}$

(5)

(Total 12 marks)