

Name of the Student: _____

Max. Marks : 26 Marks

Time : 26 Minutes

Q1.

Methanol (CH_3OH) is an important fuel that can be synthesised from carbon dioxide.

(a) The table shows some standard enthalpies of formation.

	$\text{CO}_2(\text{g})$	$\text{H}_2(\text{g})$	$\text{CH}_3\text{OH}(\text{g})$	$\text{H}_2\text{O}(\text{g})$
$\Delta H_f^\ominus / \text{kJ mol}^{-1}$	- 394	0	- 201	- 242

- (i) Use these standard enthalpies of formation to calculate a value for the standard enthalpy change of this synthesis.



(3)

- (ii) State why the standard enthalpy of formation for hydrogen gas is zero.

(1)

- (b) State and explain what happens to the yield of methanol when the total pressure is increased in this synthesis.

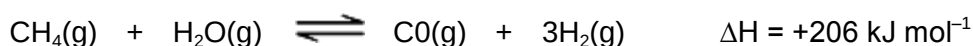


Effect on yield _____

Explanation _____

(3)

- (c) The hydrogen required for this synthesis is formed from methane and steam in a reversible reaction. The equation for this reaction is shown below.



State and explain what happens to the yield of hydrogen in this reaction when the temperature is increased.

Effect on yield _____

Explanation _____

(3)

- (d) The methanol produced by this synthesis has been described as a carbon-neutral fuel.

- (i) State the meaning of the term *carbon-neutral*.

(1)

- (ii) Write an equation for the complete combustion of methanol.

(1)

- (iii) The equation for the synthesis of methanol is shown below.



Use this equation and your answer to part (d)(ii) to deduce an equation to represent the overall chemical change that occurs when methanol behaves as a carbon-neutral fuel.

Equation _____

(1)

- (e) A student carried out an experiment to determine the enthalpy change when a sample of methanol was burned.

The student found that the temperature of 140 g of water increased by 7.5 °C when 0.011 mol of methanol was burned in air and the heat produced was used to warm the water.

Use the student's results to calculate a value, in kJ mol^{-1} , for the enthalpy change when one mole of methanol was burned.

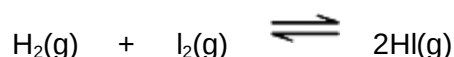
(The specific heat capacity of water is $4.18 \text{ J K}^{-1} \text{ g}^{-1}$).

(3)

(Total 16 marks)

Q2.

- (a) A mixture of 1.50 mol of hydrogen and 1.20 mol of gaseous iodine was sealed in a container of volume $V \text{ dm}^3$. The mixture was left to reach equilibrium as shown by the following equation.



At a given temperature, the equilibrium mixture contained 2.06 mol of hydrogen iodide.

- (i) Calculate the amounts, in moles, of hydrogen and of iodine in the equilibrium mixture.

Moles of hydrogen _____

Moles of iodine _____

(2)

- (ii) Write an expression for the equilibrium constant (K_c) for this equilibrium.

(1)

- (iii) K_c for this equilibrium has no units.
State why the units cancel in the expression for K_c .

(1)

- (iv) A different mixture of hydrogen, iodine and hydrogen iodide was left to reach equilibrium at the same temperature in a container of the same volume.
This second equilibrium mixture contained 0.38 mol of hydrogen, 0.19 mol of iodine and 1.94 mol of hydrogen iodide.

Calculate a value for K_c for this equilibrium at this temperature.

(2)

- (b) This question concerns changes made to the four equilibria shown in parts (b)(i) to (b)(iv). In each case, use the information in the table to help you choose from the letters **A** to **E** the best description of what happens as a result of the change described. Write your answer in the box.

Each letter may be used once, more than once or not at all.

	Position of equilibrium	Value of equilibrium constant, K_c
A	remains the same	same

B	moves to the right	same
C	moves to the left	same
D	moves to the right	different
E	moves to the left	different

- (i) Change: increase the temperature of the equilibrium mixture at constant pressure.



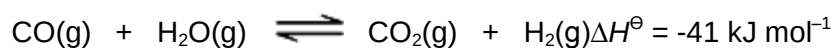
(1)

- (ii) Change: increase the total pressure of the equilibrium mixture at constant temperature.



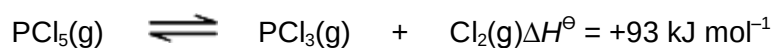
(1)

- (iii) Change: add a catalyst to the equilibrium mixture at constant temperature.



(1)

- (iv) Change: add chlorine to the equilibrium mixture at constant temperature.



(1)

(Total 10 marks)