Name of the Student:_____
Max. Marks : 21 Marks **Time : 21 Minutes**

Q1.

Sulfur trioxide decomposes on heating to form an equilibrium mixture containing sulfur dioxide and oxygen.

$$2\ SO_3(g) \rightleftharpoons 2\ SO_2(g) + O_2(g)$$

(a) A sample of sulfur trioxide was heated and allowed to reach equilibrium at a given temperature. The equilibrium mixture contained 6.08 g of sulfur dioxide.

Calculate the mass, in g, of oxygen gas in the equilibrium mixture.

Mass _____ g

(2)

(b) A different mass of sulfur trioxide was heated and allowed to reach equilibrium at 1050 K

$$2\ SO_3(g) \rightleftharpoons 2\ SO_2(g) + O_2(g)$$

The amounts of each substance in the equilibrium mixture are shown in the table.

Substance	**Amount at equilibrium / mol**
sulfur trioxide	0.320
sulfur dioxide	1.20
oxygen	0.600

For this reaction at 1050 K the equilibrium constant, $K_p = 7.62 \times 10^5$ Pa

Calculate the mole fraction of each substance at equilibrium.
Give the expression for the equilibrium constant, K_p
Calculate the total pressure, in Pa, of this equilibrium mixture.

Mole fraction SO_3 _____

Mole fraction SO_2 _____

Mole fraction O_2 _____

K_p

Total pressure _____ Pa

(4)

(c) For this reaction at 1050 K the equilibrium constant, $K_p = 7.62 \times 10^5$ Pa
For this reaction at 500 K the equilibrium constant, $K_p = 3.94 \times 10^4$ Pa

Explain how this information can be used to deduce that the forward reaction is endothermic.

_____

_____

_____

_____

_____

_____

(2)

(d) Use data from part **(c)** to calculate the value of K_p, at 500 K, for the equilibrium represented by this equation.
Deduce the units of K_p

$$SO_3(g) \rightleftharpoons SO_2(g) + \tfrac{1}{2}O_2(g)$$

K_p _____

Units _____

(2)

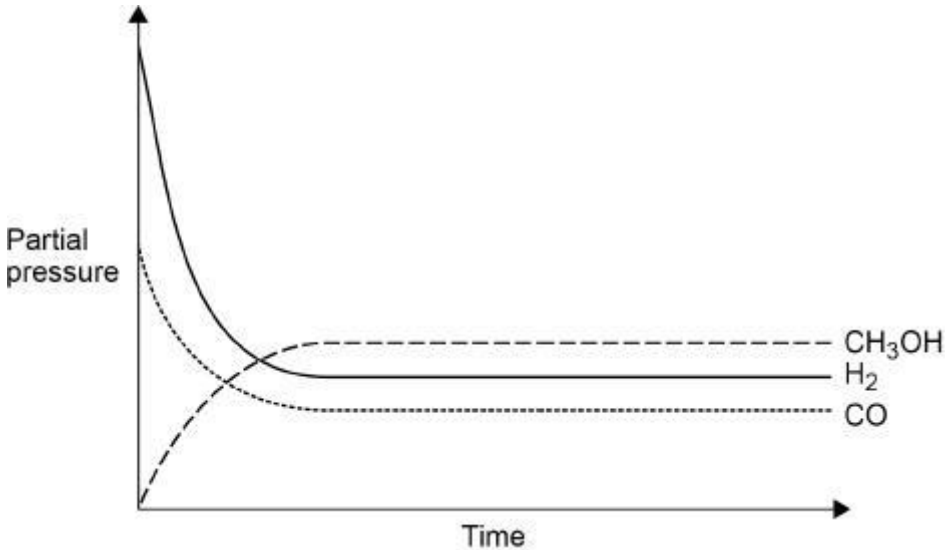
(Total 10 marks)

Q2.

Methanol can be manufactured in a reversible reaction as shown.

$CO(g) + 2\ H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H^{\ominus} = -91\ kJ\ mol^{-1}$

The graph below shows how the partial pressures change with time at a constant temperature.



(a) Draw a cross (x) on the appropriate axis of the graph when the mixture reaches equilibrium.

(1)

(b) A 0.230 mol sample of carbon monoxide is mixed with hydrogen in a 1:2 mol ratio and allowed to reach equilibrium in a sealed flask at temperature *T*.
At equilibrium the mixture contains 0.120 mol of carbon monoxide.
The total pressure of this mixture is 1.04×10^4 kPa

Calculate the partial pressure, in kPa, of hydrogen in the equilibrium mixture.

Partial pressure of hydrogen _____ kPa

(4)

(c) Give an expression for the equilibrium constant (K_p) for this reaction.

State the units.

K_p

Units _____

(2)

(d) Some more carbon monoxide is added to the mixture in part (b). The new mixture is allowed to reach equilibrium at temperature *T*.

State the effect, if any, on the partial pressure of methanol and on the value of K_p

Effect on partial pressure of methanol _____

Effect on value of K_p _____

(2)

(e) State the effect, if any, of the addition of a catalyst on the value of K_p for this equilibrium. Explain your answer.

Effect on value of K_p _____

Explanation _____

_____

_____

(2)

(Total 11 marks)