Name of the Student:_____
Max. Marks : 27 Marks **Time : 27 Minutes**

Q1.

This question is about equilibrium.

(a) 1 mol of a diester with molecular formula $C_7H_{12}O_4$ is added to 1 mol of water in the presence of a small amount of catalyst.
The mixture is left to reach equilibrium at a constant temperature.

$$C_7H_{12}O_4(l) + 2\ H_2O(l) \rightleftharpoons 2\ CH_3COOH(l) + HO(CH_2)_3OH(l)$$

At equilibrium, *x* mol of ethanoic acid are present in the mixture.

Complete **Table 1** by deducing the amounts, in terms of *x*, of the diester, water and diol present in the equilibrium mixture.

Table 1

Amount in the mixture / mol				
	Diester	**Water**	**Acid**	**Diol**
At the start	1	1	0	0
At equilibrium			*x*	

(3)

(b) Deduce the structure of the diester in part (a)

(1)

(c) A new equilibrium mixture of the substances from part (a) is prepared at a different temperature.

$$C_7H_{12}O_4(l) + 2\ H_2O(l) \rightleftharpoons 2\ CH_3COOH(l) + HO(CH_2)_3OH(l)$$

Table 2 shows the amount of each substance in this new equilibrium mixture.

Table 2

Amount in the mixture / mol				
	Diester	**Water**	**Acid**	**Diol**
At equilibrium	0.971	To be calculated	0.452	0.273

The value of the equilibrium constant, K_c is 0.161 at this temperature.

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Calculate the amount of water, in mol, in this new equilibrium mixture. Show your working.

Amount of water _____ mol

(3)

(Total 7 marks)

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Q2.

Hydrogen gas can be made by reacting ethanol with steam in the presence of a catalyst.

$$C_2H_5OH(g) + H_2O(g) \rightleftharpoons 2\ CO(g) + 4\ H_2(g)$$

(a) Give an expression for K_c for this equilibrium.

State its units.

*K*c

Units of K_c _____

(2)

(b) The table shows the amount of each substance in an equilibrium mixture in a container of volume 750 cm^3

Substance	$C_2H_5OH(g)$	$H_2O(g)$	$CO(g)$	$H_2(g)$
Amount of substance / mol	0.0750	0.156	0.110	0.220

Calculate K_c

*K*c _____

(3)

(c) The pressure of the equilibrium mixture was increased by reducing the volume of the container at constant temperature.

Predict the effect of increasing the pressure on the equilibrium yield of hydrogen. Explain your answer.

Predict the effect of increasing the pressure on the value of K_c

Effect on equilibrium yield of hydrogen _____

_____

Explanation _____

_____

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_____

_____

_____

_____

Effect on value of K_c _____

_____

(4)

(Total 9 marks)

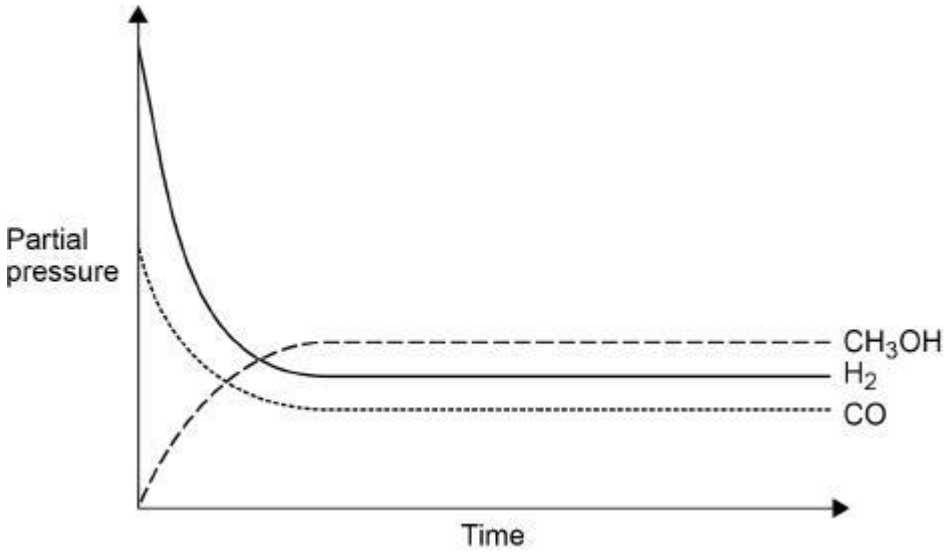
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Q3.

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)

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(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)

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