**Name of the Student**:_____
**Max. Marks : 20 Marks** **Time : 20 Minutes**

Q1.

Ethanoic acid and ethane-1,2-diol react together to form the diester ($C_6H_{10}O_4$) as shown.

$$2CH_3COOH(l) + HOCH_2CH_2OH(l) \rightleftharpoons C_6H_{10}O_4(l) + 2H_2O(l)$$

(a) Draw a structural formula for the diester $C_6H_{10}O_4$

**(1)**

(b) A small amount of catalyst was added to a mixture of 0.470 mol of ethanoic acid and 0.205 mol of ethane-1,2-diol.

The mixture was left to reach equilibrium at a constant temperature.

Complete **Table 1**.

**Table 1**

| **Amount in the mixture / mol** | | | | |
|---|---|---|---|---|
| | $CH_3COOH$ | $HOCH_2CH_2OH$ | $C_6H_{10}O_4$ | $H_2O$ |
| At the start | 0.470 | 0.205 | 0 | 0 |
| At equilibrium | 0.180 | | | |

Space for working

**(3)**

(c) Write an expression for the equilibrium constant, $K_c$, for the reaction.

The total volume of the mixture does not need to be measured to allow a correct value for $K_c$ to be calculated.

Justify this statement.

Expression

Justification _____

_____

**(2)**

(d) A different mixture of ethanoic acid, ethane-1,2-diol and water was prepared and left to reach equilibrium at a different temperature from the experiment in part (b)

The amounts present in the new equilibrium mixture are shown in **Table 2**.

**Table 2**

| **Amount in the mixture / mol** | | | | |
|---|---|---|---|---|
| | $CH_3COOH$ | $HOCH_2CH_2OH$ | $C_6H_{10}O_4$ | $H_2O$ |
| At new equilibrium | To be calculated | 0.264 | 0.802 | 1.15 |

The value of $K_c$ was 6.45 at this different temperature.

Use this value and the data in **Table 2** to calculate the amount, in mol, of ethanoic acid present in the new equilibrium mixture.

Give your answer to the appropriate number of significant figures.

Amount of ethanoic acid _____ mol

**(3)**

**(Total 9 marks)**

**Q2.**

Methanol can be manufactured by the reaction of carbon monoxide with hydrogen

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

In an experiment, 0.73 mol of carbon monoxide was heated with 1.25 mol of hydrogen. An equilibrium mixture was formed that contained 0.43 mol of methanol.

(a) Calculate the amount, in moles, of each reactant present at equilibrium.

Amount of carbon monoxide = ____ mol

Amount of hydrogen = _____ mol

**(2)**

(b) Write an expression for the equilibrium constant, $K_c$, for this reaction.

_____

**(1)**

(c) In another experiment at a different temperature, the equilibrium mixture contained 0.452 mol of carbon monoxide, 0.106 mol of hydrogen and 0.273 mol of methanol in a flask of volume $9.40 \times 10^3$ cm$^3$.

Calculate the value of the equilibrium constant, $K_c$, at this temperature and state the units.

$K_c$ = _____ Units = _____

**(4)**

(d) The total pressure of this equilibrium mixture in the flask was 482.9 kPa.

Calculate the temperature, in °C, of the equilibrium mixture.
(The ideal gas constant $R$ = 8.31 J mol$^{-1}$ K$^{-1}$)

Temperature = _____ °C

**(4)**

**(Total 11 marks)**