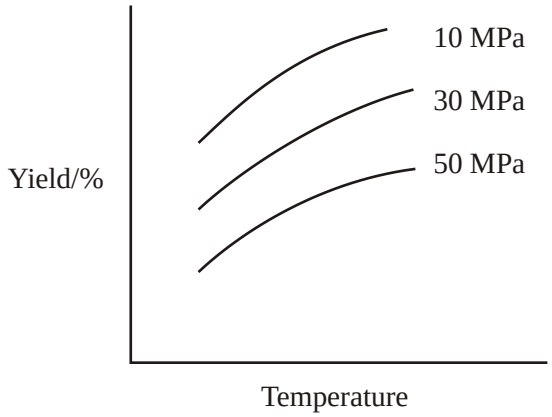
AQA A2 CHEMISTRY

TOPIC 4.2

EQUILIBRIA

BOOKLET OF PAST EXAMINATION QUESTIONS

1. (a) The diagram below shows the effect of temperature and pressure on the equilibrium yield of the product in a gaseous equilibrium.



(i) Use the diagram to deduce whether the forward reaction involves an increase or a decrease in the number of moles of gas. Explain your answer.

Change in number of moles .....

Explanation .....

.....

.....

(ii) Use the diagram to deduce whether the forward reaction is exothermic or endothermic.
Explain your answer.

The forward reaction is .....

Explanation .....

.....

.....

(6)

(b) When a 0.218 mol sample of hydrogen iodide was heated in a flask of volume V dm^3, the following equilibrium was established at 700 K.

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

The equilibrium mixture was found to contain 0.023 mol of hydrogen.

(i) Calculate the number of moles of iodine and the number of moles of hydrogen iodide in the equilibrium mixture.

Number of moles of iodine.....

Number of moles of hydrogen iodide.....

.....

(ii) Write an expression for K_c for the equilibrium.

.....

.....

(iii) State why the volume of the flask need not be known when calculating a value for K_c.

.....

.....

(iv) Calculate the value of K_c at 700 K.

.....

.....

.....

.....

(v) Calculate the value of K_c at 700 K for the equilibrium

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

.....

.....

(7)
(Total 13 marks)

2. Acid **X** reacts with methanol to form ester **Y** according to the following equation.

$$\begin{matrix}CH_2COOH\\ |\\ CH_2COOH\end{matrix} + 2\,CH_3OH \rightleftharpoons \begin{matrix}CH_2COOCH_3\\ |\\ CH_2COOCH_3\end{matrix} + 2H_2O \qquad \Delta H^{\ominus} = -15\ kJ\,mol^{-1}$$

acid **X** ester **Y**

A mixture of 0.25 mol of **X** and 0.34 mol of methanol was left to reach equilibrium in the presence of a small amount of concentrated sulphuric acid. The equilibrium mixture thus formed contained 0.13 mol of **Y** in a total volume of V dm^3.

(a) Using **X** to represent the acid and **Y** to represent the ester, write an expression for the equilibrium constant, K_c, for this reaction.

(1)

(b) Calculate the number of moles of **X**, the number of moles of methanol and the number of moles of water in the equilibrium mixture.

Moles of **X** .....

Moles of methanol .....

Moles of water .....

(3)

(c) State why the volume V need not be known in calculating the value of K_c for the reaction.

.....

.....

(1)

(d) Calculate the value of K_c for this reaction and deduce its units.

Calculation .....

.....

.....

.....

Units of K_c .....

.....

(3)

(e) State the effect, if any, of increasing the temperature on the value of K_c

.....

(1)

(Total 9 marks)

3. As a first step in the manufacture of nitric acid it has been suggested that nitrogen monoxide, NO, can be formed from nitrogen and oxygen in a reversible reaction.

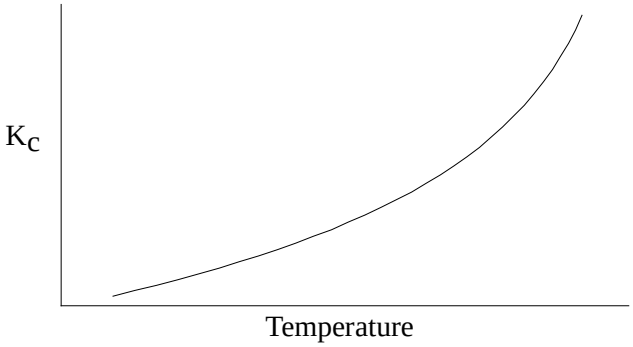
(a) Write an equation for this reaction and deduce an expression for the equilibrium constant, K_c

Equation.....

K_c .....

(2)

(b) The sketch graph below shows how the value of K_c for this reaction changes with temperature.



Use this graph to deduce whether the reaction is exothermic or endothermic.

Explain your answer.

.....

.....

(2)

(c) The value of K_c for this reaction is 1×10^{-5} at 1500 K.

Explain the significance of this value for an industrial chemist interested in manufacturing nitrogen monoxide by the direct combination of the elements.

.....

.....

(2)

(d) When cooled, nitrogen monoxide reacts with oxygen to form gaseous nitrogen dioxide, NO_2, in a reversible reaction.

(i) Write an equation for this reaction.

.....

(ii) State how an increase in pressure would change the position of the equilibrium and the value of the equilibrium constant for this reaction.

Change in equilibrium position.....

Change in equilibrium constant.....

(3)

(Total 9 marks)

4. The manufacture of methanol can be achieved in two stages.

In the first stage, methane and steam react according to the following equation.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H^{\ominus} = +210 \text{ kJ mol}^{-1}$$

Discuss, with reasons, the effects of increasing separately the temperature and the pressure on the yield of the products and on the rate of this reaction.

(6)
(Total 6 marks)

5. The reaction between hydrogen and iodine can be represented by the following equation:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H = +52 \text{ kJ mol}^{-1}$$

(a) Write a K_C expression for the decomposition of hydrogen iodide. At a given temperature, the value of K_C for this reaction is 20. What will be the value of K_C for the reaction between hydrogen and iodine at this temperature?

(2)

(b) The pressure of an equilibrium mixture of hydrogen iodide, hydrogen and iodine was increased. State what, if anything, would happen to:

(i) the rates of both forward and reverse reactions;

(2)

(ii) the position of equilibrium;

(1)

(iii) the value of the equilibrium constant.

(1)
(Total 6 marks)

6. (a) A flask containing a mixture of 0.200 mol of ethanoic acid and 0.110 mol of ethanol was maintained at 25 °C until the following equilibrium had been established.

$$CH_3COOH(l) + C_2H_5OH(l) \rightleftharpoons CH_3COOC_2H_5(l) + H_2O(l)$$

The ethanoic acid present at equilibrium required 72.5 cm^3 of a 1.50 mol dm^{-3} solution of sodium hydroxide for complete reaction.

(i) Calculate the value of the equilibrium constant, K_c, for this reaction at 25 °C.

(ii) The enthalpy change for this reaction is quite small. By reference to the number and type of bonds broken and made, explain how this might have been predicted.

(9)
(Total 9 marks)

7. When ammonia gas is heated, a homogeneous, dynamic equilibrium is established between ammonia and its constituent elements. This decomposition is endothermic.

(a) Explain the terms *homogeneous*, *dynamic* and *equilibrium*.
Write an equation for this decomposition and derive an expression for the equilibrium constant, K_c

(5)

(b) State and explain the conditions under which a high equilibrium concentration of hydrogen would be obtained.

(4)

(c) The decomposition of ammonia might in the future be used as an industrial method for the manufacture of hydrogen.
Explain why an industrial chemist might decide to use conditions different from those you have given in part (b) if large quantities of hydrogen were to be produced by this decomposition. Discuss the effect that using a catalyst would have on the equilibrium yield and on the amount of hydrogen which could be produced in a given time.

(6)
(Total 15 marks)