“*Reverse gear*”

Y13 UNIT 4 TEST 2

4.2 EQUILIBRIA

Bonne Chance!

Answer all questions

Total 50 marks

Name: _____

SECTION A TOTAL ……/39

SECTION B TOTAL ……/11

TOTAL ……/50

= ……%

Grade _____

SECTION A

1. At a temperature of 107°C, the reaction

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

reaches equilibrium under a pressure of 1.59 MPa with 0.122 mol of carbon monoxide and 0.298 mol of hydrogen present at equilibrium in a vessel of volume 1.04 dm^3.

Use these data to answer the questions that follow.

(a) Assuming ideal gas behaviour, determine the total number of moles of gas present. Hence calculate the number of moles of methanol in the equilibrium mixture.

Total moles.....

.....

Moles of methanol.....

.....

(3)

(b) Calculate the value of the equilibrium constant, *K*c, for this reaction and state its units.

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(3)
(Total 6 marks)

2. (a) The expression for an equilibrium constant, K_c, for a homogeneous equilibrium reaction is given below.

$$K_c = \frac{[A]^2[B]}{[C]\,[D]^3}$$

(i) Write an equation for the forward reaction.

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(ii) Deduce the units of K_c

.....

(iii) State what can be deduced from the fact that the value of K_c is larger when the equilibrium is established at a lower temperature.

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(3)

(b) A 36.8 g sample of N_2O_4 was heated in a closed flask of volume 16.0 dm^3. An equilibrium was established at a constant temperature according to the following equation.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

The equilibrium mixture was found to contain 0.180 mol of N_2O_4

(i) Calculate the number of moles of N_2O_4 in the 36.8 g sample.

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(ii) Calculate the number of moles of NO_2 in the equilibrium mixture.

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.....

(iii) Write an expression for K_c and calculate its value under these conditions.

Expression for K_c .....

.....

Calculation .....

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(iv) Another 36.8 g sample of N_2O_4 was heated to the same temperature as in the original experiment, but in a larger flask. State the effect, if any, of this change on the position of equilibrium and on the value of K_c compared with the original experiment.

Effect on the position of equilibrium .....

Effect on the value of K_c .....

(9)

(Total 12 marks)

3. Tetrafluoroethene, C_2F_4, is obtained from chlorodifluoromethane, $CHClF_2$, according to the equation:

$$2CHClF_2(g) \rightleftharpoons C_2F_4(g) + 2HCl(g) \qquad \Delta H^{\ominus} = +128 \text{ kJ mol}^{-1}$$

(a) A 1.0 mol sample of $CHClF_2$ is placed in a container of volume 18.5 dm^3 and heated.

When equilibrium is reached, the mixture contains 0.20 mol of $CHClF_2$

(i) Calculate the number of moles of C_2F_4 and the number of moles of HCl present at equilibrium.

Number of moles of C_2F_4 .....

Number of moles of HCl .....

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

.....

(iii) Calculate a value for K_c and give its units.

Calculation .....

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Units .....

(6)

(b) (i) State how the temperature should be changed at constant pressure to increase the equilibrium yield of C_2F_4

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(ii) State how the total pressure should be changed at constant temperature to increase the equilibrium yield of C_2F_4

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(2)

(Total 8 marks)

4. Nitrogen dioxide dissociates according to the following equation.

$$2NO_2(g) \rightleftharpoons 2NO(g) + O_2(g)$$

When 21.3 g of nitrogen dioxide were heated to a constant temperature, *T*, in a flask of volume 11.5 dm^3, an equilibrium mixture was formed which contained 7.04 g of oxygen.

(a) (i) Calculate the number of moles of oxygen present in this equilibrium mixture and deduce the number of moles of nitrogen monoxide also present in this equilibrium mixture.

Number of moles Of O_2 at equilibrium .....

.....

Number of moles of NO at equilibrium .....

(ii) Calculate the number of moles in the original 21.3 g of nitrogen dioxide and hence calculate the number of moles of nitrogen dioxide present in this equilibrium mixture.

Original number of moles of NO_2 .....

.....

Number of moles of NO_2 at equilibrium .....

.....

(4)

(b) Write an expression for the equilibrium constant, K_c, for this reaction. Calculate the value of this constant at temperature T and give its units.

Expression for K_c .....

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Calculation .....

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(4)

(c) The total number of moles of gas in the flask is 0.683. Use the ideal gas equation to determine the temperature *T* at which the total pressure in the flask is 3.30×10^5 Pa. (The gas constant $R = 8.31$ J $K^{-1}mol^{-1}$)

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(3)

(d) State the effect on the equilibrium yield of oxygen and on the value of K_c when the same mass of nitrogen dioxide is heated to the same temperature *T*, but in a different flask of greater volume.

Yield of oxygen .....

Value of K_c .....

(2)

(Total 13 marks)

SECTION B

5. The manufacture of sulphuric acid is carried out on a large scale in most industrialised countries because it is needed by many other industries. In most countries the raw material is sulphur. The process consists of three main stages - the burning of sulphur in air, the conversion of sulphur dioxide to sulphur trioxide and the formation of sulphuric acid. The equation for the conversion to sulphur trioxide is

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

(a) For the conversion to sulphur trioxide, the effect of temperature on the percentage yield at equilibrium is shown in **Figure 1**.

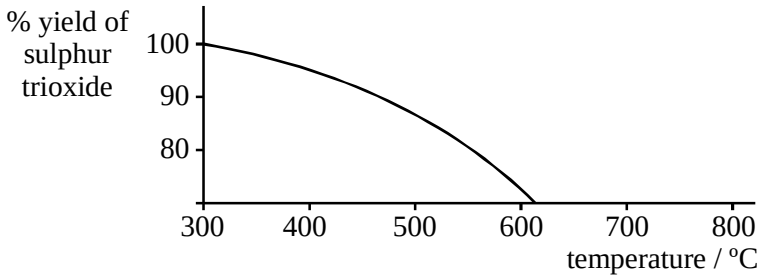

Figure 1

(i) State whether this reaction is exothermic or endothermic and justify your answer by reference to **Figure 1**.

(2)

(ii) Give the name of the catalyst used in this reaction. State the effect of the catalyst on the percentage yield at equilibrium of sulphur trioxide and on the rates of both forward and reverse reactions.

(4)

(iii) A typical operating temperature is 450 °C. State **one** advantage and **one** disadvantage of operating the process at a temperature 50 °C lower.

(2)

(b) The operating pressure for the conversion of sulphur dioxide to sulphur trioxide is slightly higher than atmospheric pressure.

(i) State the effect on the rate of the reaction of using a much higher pressure.

(1)

(ii) State the effect of using this much higher pressure on the percentage yield at equilibrium of sulphur trioxide and give a reason for your answer.

(2)

(Total 11 marks)