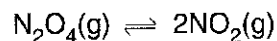


Answer **all** questions.

- 1 A chemist set up an equilibrium system between dinitrogen tetroxide, N_2O_4 , and nitrogen dioxide, NO_2 , at 25°C .



The equilibrium concentrations were: $\text{N}_2\text{O}_4(\text{g})$, $0.0390 \text{ mol dm}^{-3}$; $\text{NO}_2(\text{g})$, $0.0150 \text{ mol dm}^{-3}$.

- (a) (i) Write the expression for K_c in this equilibrium system.

[1]

- (ii) Calculate K_c for this equilibrium. State the units.

[2]

- (b) The standard enthalpy changes of formation of N_2O_4 and NO_2 are given below.

compound	$\Delta H_f^\ominus/\text{kJ mol}^{-1}$
N_2O_4	+9
NO_2	+33

Calculate the standard enthalpy change for the forward reaction in this equilibrium.

[2]

- (c) This equilibrium system was heated at constant pressure. How would you expect the relative proportions of N_2O_4 and NO_2 to change? Explain your answer.

change

explanation

.....
.....[3]

- (d) NO_2 and N_2O_4 are both poisonous. After this investigation, the chemist needed to dispose of 0.00465 mol N_2O_4 safely. The chemist decided to do this by reacting the N_2O_4 with an alkali and chose aqueous sodium hydroxide.



Calculate the minimum volume of $0.300 \text{ mol dm}^{-3}$ $\text{NaOH}(\text{aq})$ required to dispose of this amount of N_2O_4 .

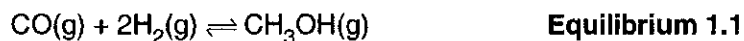
[3]

[Total : 11]

Answer **all** the questions.

- 1 Syngas is a mixture of carbon monoxide and hydrogen gases, used as a feedstock for the manufacture of methanol.

A dynamic equilibrium was set up between carbon monoxide, CO, hydrogen, H₂, and methanol, CH₃OH. The equilibrium system is shown by Equilibrium 1.1 below.



The equilibrium concentrations of the three components of this equilibrium are shown below.

component	CO(g)	H ₂ (g)	CH ₃ OH(g)
equilibrium concentration /mol dm ⁻³	3.1 × 10 ⁻³	2.4 × 10 ⁻²	2.6 × 10 ⁻⁵

- (a) State **two** features of a system that is in *dynamic equilibrium*.

.....

[2]

- (b) (i) Write the expression for K_c for this equilibrium system.

[2]

- (ii) Calculate the numerical value of K_c for this equilibrium.

[2]

- (c) The pressure was increased whilst keeping the temperature constant. The system was left to reach equilibrium. The equilibrium position of Equilibrium 1.1 shifted to the right.

- (i) Explain why the equilibrium moved to the right.

.....
[2]

- (ii) What is the effect, if any, on K_c ?

.....[1]

(iii) State and explain the effect on the rates of the forward and reverse reactions

- when the pressure was first changed
- when the system reached equilibrium.

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.....[4]

(d) The temperature was increased whilst keeping the pressure constant. The system was left to reach equilibrium. The value of K_c for Equilibrium 1.1 decreased.

(i) Explain what happens to the equilibrium position of Equilibrium 1.1.

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.....[2]

(ii) Deduce the sign of the enthalpy change for the forward reaction shown in Equilibrium 1.1. Explain your reasoning.

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.....[1]

(iii) Explain how the partial pressure of $\text{CH}_3\text{OH}(\text{g})$ would change as the system moves towards equilibrium.

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.....[1]

[Total: 17]