Chemical Equilibrium

Date Planned : __ / __ / __	Daily Tutorial Sheet	Expected Duration : 90 Min
Actual Date of Attempt : __ / __ / __	Level-0	Exact Duration :_____

Very Short Answer Type (1 Mark)

1. What is K_c for the following equilibrium?

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$. When the equilibrium concentration of each substance is $[SO_2] = 0.60\,M$, $[O_2] = 0.82\,M$ and $[SO_3] = 1.90\,M$?

2. The equilibrium constant expression for a gas reaction is $K_c = \dfrac{[NH_3]^4[O_2]^5}{[NO]^4[H_2O]^6}$.

Write the balanced chemical equation corresponding to this expression.

3. State the characteristics of equilibrium in physical processes.

4. Describe liquid-vapour equilibrium.

5. Define homogeneous equilibrium?

6. State the Le Chatelier's Principle?

Short Answer Type-I (2 Marks)

7. At a certain temperature and a total pressure of 10^5Pa, iodine vapour contains 40% by volume of iodine atoms $[I_2(g) \rightleftharpoons 2I(g)]$ Calculate K_p for the equilibrium.

8. Find out the value of K_c for each of the following equilibria from the value of K_p

(a) $2NOCl(g) \rightleftharpoons 2\,NO(g) + Cl_2(g)$, $K_p = 1.8 \times 10^{-2}$ at 500 K

(b) $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$, K_p=167 at 1073 K

9. Explain why pure liquids and solids can be ignored while writing the equilibrium constant expression.

10. A sample of HI(g) is placed in a flask at a pressure of 0.2 atm. At equilibrium, the partial pressure of HI(g) is 0.04 atm. What is K_p for the given equilibrium ?

11. What is the relation between the equilibrium constant of the forward reaction and the equilibrium constant of the reverse reaction ?

12. What is the relation between the activity of a gaseous component and its partial pressure ?

13. In the reaction $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

PCl_5, PCl_3 and Cl_2 are at equilibrium at 500 K. The concentration of PCl_3 and Cl_2 is 1.59 M. $K_c = 1.79$. Calculate the concentration of PCl_5.

Short Answer Type-II (3 Marks)

14. Reaction between nitrogen and oxygen takes place as follows:

$$2\,N_2(g) + O_2(g) \rightleftharpoons 2\,N_2O(g)$$

If a mixture of 0.482 mol of N_2 and 0.933 mol of O_2 is placed in a reaction vessel of volume 10L and allowed to form N_2O at a temperature for which $K_c = 2.0 \times 10^{-37}$. Determine the composition of the equilibrium mixture.

15. A mixture of 1.57 mol of N_2, 1.92 mol of H_2 and 8.13 mol of NH_3 is introduced into a 20 L reaction vessel at 500 K. At this temperature, the equilibrium constant, K_c for the reaction, $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ is 1.7×10^2. Is the reaction mixture at equilibrium? If not, what is the direction of the net reaction?

16. Predict which of the following reaction will have appreciable concentration of reactants and products :

(a) $Cl_2(g) \rightleftharpoons 2Cl(g),\ K_c = 5 \times 10^{-39}$

(b) $Cl_2(g) + 2NO(g) \rightleftharpoons 2NOCl(g),\ K_c = 3.7 \times 10^8$

(c) $Cl_2(g) + 2NO_2(g) \rightleftharpoons 2NO_2Cl(g),\ K_c = 1.8$

17. At 1,000 K in the reaction $CO_2(g) + C(s) \rightleftharpoons 2CO(g)$

The value of $p_{CO_2} = 0.48$ bar and $p_{CO} = 0$ bar. Pure graphite is present. The equilibrium partial pressures of CO and CO_2 are 0.66 bar and 0.15 bar respectively. Calculate K_p of the reaction.

18. A mixture of 1.57 mol of N_2, 1.92 mol of H_2 and 8.17 mol of NH_3 is introduced in a 20 L reaction vessel at 500 K. At this temperature, the equilibrium constant K_c for the reaction is 1.7×10^{-2}. Is the reaction at equilibrium? The reaction is $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

19. The value of K_c for the reaction $2A \rightleftharpoons B + C$ is 2×10^{-2}. At a given time the composition of the reaction mixture is $[A] = [B] = [C] = 3 \times 10^{-3}$M. What will be the direction of the reaction ?

Long Answer Type (5 Marks)

20. Which of the following reactions will get affected by increasing the pressure? Also mention whether change will cause the reaction to go into forward or backward direction?

(i) $COCl_2(g) \rightleftharpoons CO(g) + Cl_2(g)$ **(ii)** $CH_4(g) + 2\,S_2(g) \rightleftharpoons CS_2(g) + 2H_2S(g)$

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

21. Describe the effect of : (a) addition of H_2 (b) addition of CH_3OH (c) removal of CO (d) removal of CH_3OH, on the equilibrium of the reaction : $2H_2(g) + CO(g) \rightleftharpoons CH_3OH(g)$

22. At 473 K, equilibrium constant, Kc, for the decomposition of phosphorus pentachloride, PCl_5 is 8.3×10^{-3}. If decomposition is depicted as:

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g),\ \Delta_r H^\circ = 124.0\,kJ\,mol^{-1}$$

(a) Write an expression for K_c for the reaction?

(b) What is the value of K_c for the reverse reaction at the same temperature?

(c) What would be the effect on K_c if (i) more PCl_5 is added (ii) pressure is increased (iii) temperature is increased?

23. **(i)** List the applications of equilibrium constants.

(ii) Predict the extent of reaction when the value of equilibrium constant is very high.

24. **(i)** What is the effect of adding a catalyst to a reversible reaction?

(ii) What is the effect of adding an inert gas to a reversible reaction?

(iii) How does temperature change affect a reversible reaction?

(iv) The equilibrium constant for a reaction is 2×10^{-23} at 25°C and 2×10^{-2} at 50°C. Is the reaction endothermic or exothermic ?

25. **(i)** Mention at least three ways by which the concentration of SO_3 can be increased in the following reaction in a state of equilibrium. $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) + \text{heat}$

(ii) In a reaction $A + B \rightleftharpoons C + D$, what will happen to the equilibrium state if concentration of A is increased?