UNIT 7

EQUILIBRIUM

Answer the questions. (1 Score each)

1. Give the Arrhenius concept of acids and bases?

Ans. According to Arrhenius concept, acids are substances which give hydrogen ion (H^+) or hydronium ion (H_3O^+) in aqueous solution and bases are substances which give hydroxyl ion (OH^-) in aqueous solution.

2. Give one example each for Arrhenius acid and base?

Ans. **HCl is an acid.**

NaOH is a base.

3. Write the expression for equilibrium constant Kp for the following equilibrium?

$$2NOCl_{(g)} \rightleftarrows 2NO_{(g)} + Cl_{2(g)}$$

$$K_P = \frac{P^2_{NO} \times P_{Cl_2}}{P^2_{NOCl}}$$

4. What is Conjugate acid – base pair?

Ans.: Acid - base pairs which are differed by a proton (H+) are called conjugate acid - base pair.

5.Define the pH?

Ans.: pH is defined as the negative logarithm of the hydrogen ion or hydronium ion concentration in moles per litre (i.e. molarity).

$pH = -\log[H^+]$ or $pH = -\log[H_3O^+]$

6. Select the Lewis acid from the following: (NH_3, OH^-, BCl_3, Cl^-)

Ans.: BCl_3

7. .... is an example for buffer solution.

a) Acetic acid b) Sodiam acetate c) Salt solution d) Blood

Ans.: d) Blood

8. Write the expression for ionic product (K_W) of water?

Ans.: $K_W = [H^+][OH^-]$

9. $_pH + _pOH$ = ---------

Ans.: 14 or $_pK_W$

10. Write conjugate acid and conjugate base of HCO_3^-?

Ans.: Conjugate acid of HCO_3^- is H_2CO_3

Conjugate base of HCO_3^- is CO_3^{2-}

11. Write an equation for equilibrium constant in terms of concentration (Kc) for the equilibrium reaction given below.

Ans.: $Ag_2O_{(s)} + 2HNO_{3(aq)} \rightleftarrows 2AgNO_{3(aq)} + H_2O_{(l)}$

$$K_C = \frac{[AgNO_3]^2}{[HNO_3]^2}$$

Answer the questions. (2 Score each)

12. Define buffer solutions and write one example for an acidic buffer?

Ans.: Solutions which resist the change in pH on dilution or with the addition of small amount of acid or alkali is called Buffer solution.

A mixture of acetic acid and sodium acetate acts as an acidic buffer .

13. Give the relation between Kp and Kc, for the reaction given below?

$2NOCl(g) \rightleftarrows 2NO(g)+Cl_2(g)$

Ans.: $Kp = Kc\,(RT)^{\Delta n}$

Here $\Delta n = n_{P(g)} - n_{R(g)}$

= 3–2 = 1

So, Kp = Kc RT

14. H_2O and HSO_4^- can act as Bronsted acid and base. .For each case give the corresponding conjugate acid and conjugate base.

	Conjugate Acid	Conjugate Base
H_2O	H_3O^+	OH^-
HSO_4^-	H_2SO_4	SO_4^{2-}

15. Classify the following into Lewis acid and Lewis base?

i) H_2O ii) NH_3 iii) $AlCl_3$ iv) H^+

Ans:

Lewis Acid	Lewis Base
$AlCl_3$	H_2O
H^+	NH_3

16. (a) Write the expression for equilibrium constant, Kc for the reaction

$4\,NH_{3(g)} + 5\,O_{2(g)} \rightleftarrows 4\,NO_{(g)} + 6\,H_2O_{(g)}$

b) What happens to the value of the equilibrium constant (Kc) when the above reaction is reversed?

(a) $$K_C = \frac{[NO]^4\,[H_2O]^6}{[NH_3]^4[O_2]^5}$$

(b) When the reaction is reversed, the new equilibrium constant (Kc') = $\frac{1}{Kc}$

17. $CaCO_3\,(s) \rightleftarrows CaO\,(s) + CO_2\,(g)$

a) Write down the expression for Kp.

b) What is the relation between Kp and Kc in the above reaction?

Ans **a) $K_p = P_{CO_2}$**

b) Here $\Delta n = n_{P(g)} - n_{R(g)}$

$= 1 - 0 = 1$

So $K_p = K_c\,RT$

18. Examine the chemical equilibrium,

$4NH_3\,(g) + 5O_2(g) \rightleftarrows 4NO(g) + 6H_2O(g)$

(a) Write the expression for equilibrium constant(Kc) for the above equilibrium.

(b) What happens to Kc, if the balanced equation is multiplied throughout by a factor of 2 ?

Ans: **(a)** $$K_C = \frac{[NO]^4\,[H_2O]^6}{[NH_3]^4[O_2]^5}.$$

(b) If K_C is multiplied throughout by a factor of 2, then the new K_C will be K_C^2

Answer the questions. (3 Score each)

19. At equilibrium, the concentrations of $N_2 = 3.0x10^{-3}M$, $O_2 = 4.2x10^{-3}M$ and $NO = 2.8x10^{-3}M$ in a sealed vessel at 800K. What will be Kc for the reaction $N_{2(g)} + O_{2(g)} \rightleftarrows 2NO_{(g)}$?

Ans:

$$K_c = \frac{[NO]^2}{[N_2][O_2]}$$

$$= \frac{(2.8X10^{-3}M)^2}{(3.0X10^{-3}M)(4.2X10^{-3}M)}$$

$$= 0.622$$

20. For the equilibrium, $2NOCl_{(g)} \rightleftarrows 2NO_{(g)} + Cl_{2(g)}$, the value of equilibrium constant Kp is 1.8×10^{-2} at 500 K. Calculate Kc for this reaction at the same temperature?

Ans:

$Kp = 1.8 \times 10^{-2}$, $R = 0.083$ L bar/K/mol

$\Delta n = n_{P(g)} - n_{R(g)}$

$= 3 - 2 = 1$

$T = 500K$

$Kp = Kc(RT)^{\Delta n}$

$$1.8X10^{-2} = K_c(0.083 \times 500)^1$$

$$K_C = \frac{1.8X10^{-2}}{0.083X500}$$

$$= 4.33X10^{-4}$$

21. If the concentration of hydrogen ion in a soft drink is 3×10^{-3} M, calculate its pH?

Ans:

$$[H^+] = 3X10^{-3}M$$

$$pH = -\log[H^+]$$

$$= -\log(3X10^{-3})$$

$$= 2.523$$

22. Calculate the pH of 1×10^{-2} molar aqueous solution of H_2SO_4?

H_2SO_4 $2H^+ + SO_4^{2-}$

$[H^+] = (2x1x10^{-2})$

$P^H = -\log[H^+] = -\log(2x10^{-2})$

$=1.6989$

Answer the questions. (4 Score each)

23.(a) Write the expression for equilibrium constant Kp for the following equilibrium?

$2NOCl(g) \rightleftarrows 2NO(g) + Cl_2(g)$

(b) Find the value of Kc for the above equilibrium if the value of Kp is 1.8×10^{-2} atm at 600 K?

(R= 0.0821 L atm $K^{-1}mol^{-1}$)

Ans: (a) $K_p = \frac{(P_{NO})^2 \times (P_{Cl_2})}{(P_{NOCl})^2}$

(b) Here Kp= 1.8 x 10^{-2}, R = 0.0821 atm/K/mol,

$\Delta n = n_{P(g)} - n_{R(g)} = 3 - 2 = 1$

T = 600K

$Kp = Kc(RT)^{\Delta n}$

$1.8 \times 10^{-2} = Kc\ (0.0821 \times 600)^1$

$K_C = \frac{1.8 \times 10^{-2}}{0.0821 \times 600}$

$Kc = 3.65 \times 10^{-4}$

24. Derive the relation between K_P and K_c?

Ans: From Ideal gas equation PV= nRT

$P = \frac{nRT}{V}$

Here, n/V = Concentration in mol/m^3

Then p= CRT , also at constant temperature, pressure of the gas is proportional to its concentration.

Consider a general reaction,

$aA + bB \rightleftharpoons cC + dD$

Then $K_P = \frac{(P_C{}^c) \times (P_D{}^d)}{(P_A{}^a) \times (P_B{}^b)}$

Rearranging pressure in terms of CRT we get,

$$K_P = \frac{[C]^c \times [D]^d \times (RT)^{(c+d)}}{[A]^a \times [B]^b \times (RT)^{(a+b)}}$$

$$= \frac{[C]^c \times [D]^d}{[A]^a \times [B]^b} (RT)^{(c+d)-(a+b)}$$

$$= \frac{[C]^c \times [D]^d}{[A]^a \times [B]^b} (RT)^{\Delta n}$$

$$= K_c(RT)^{\Delta n}$$

Thus $K_P = K_c(RT)^{\Delta n}$

Here Δn = (number of moles of gaseous products) -(number of moles of gaseous reactants)