

UNIT 7

EQUILIBRIUM

Answer the questions. (1 Score each)

1. Give the Arrhenius concept of acids and bases?

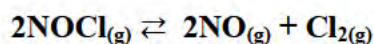
Ans. According to Arrhenius concept, acids are substances which give hydrogen ion (H^+) or hydronium ion (H_3O^+) in aqueous solution and bases are substances which give hydroxyl ion (OH^-) in aqueous solution.

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 K_p for the following equilibrium?



$$K_p = \frac{P_{NO}^2 \times P_{Cl_2}}{P_{NOCl}^2}$$

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).

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

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) Sodium 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. $pH + pOH = \text{-----}$

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 (K_c) for the equilibrium reaction given below.

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

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

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 K_p and K_c , for the reaction given below?

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

Ans.: $K_p = K_c (RT)^{\Delta n}$

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

$= 3 - 2 = 1$

So, $K_p = K_c RT$

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

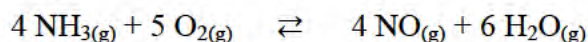
	Conjugate Acid	Conjugate Base
H_2O	H_3O^+	OH^-
HSO_4^-	H_2SO_4	SO_4^{2-}

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 ₂ O
H ⁺	NH ₃

16. (a) Write the expression for equilibrium constant, K_c for the reactionb) What happens to the value of the equilibrium constant (K_c) when the above reaction is reversed?

$$(a) \quad K_c = \frac{[\text{NO}]^4 [\text{H}_2\text{O}]^6}{[\text{NH}_3]^4 [\text{O}_2]^5}$$

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

17. $\text{CaCO}_3(\text{s}) \rightleftharpoons \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$ a) Write down the expression for K_p.b) What is the relation between K_p and K_c in the above reaction?Ans a) $K_p = P_{\text{CO}_2}$

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

$$= 1 - 0 = 1$$

$$\text{So } K_p = K_c RT$$

18. Examine the chemical equilibrium,

(a) Write the expression for equilibrium constant(K_c) for the above equilibrium.(b) What happens to K_c, if the balanced equation is multiplied throughout by a factor of 2 ?

$$\text{Ans: (a) } K_c = \frac{[\text{NO}]^4 [\text{H}_2\text{O}]^6}{[\text{NH}_3]^4 [\text{O}_2]^5}$$

(b) If K_c is multiplied throughout by a factor of 2, then the new K_c will be K_c²

Answer the questions. (3 Score each)

19. At equilibrium, the concentrations of N₂ = 3.0x10⁻³M, O₂ = 4.2x10⁻³M and NO = 2.8x10⁻³M in a sealed vessel at 800K. What will be K_c for the reaction N_{2(g)} + O_{2(g)} ⇌ 2NO_(g)?

Ans:

$$\begin{aligned} K_c &= \frac{[\text{NO}]^2}{[\text{N}_2][\text{O}_2]} \\ &= \frac{(2.8 \times 10^{-3} \text{M})^2}{(3.0 \times 10^{-3} \text{M})(4.2 \times 10^{-3} \text{M})} \\ &= 0.622 \end{aligned}$$

20. For the equilibrium, $2\text{NOCl}_{(g)} \rightleftharpoons 2\text{NO}_{(g)} + \text{Cl}_{2(g)}$, the value of equilibrium constant K_p is 1.8×10^{-2} at 500 K. Calculate K_c for this reaction at the same temperature?

Ans:

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

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

$$= 3 - 2 = 1$$

$$T = 500 \text{ K}$$

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

$$1.8 \times 10^{-2} = K_c (0.083 \times 500)^1$$

$$K_c = \frac{1.8 \times 10^{-2}}{0.083 \times 500}$$

$$= 4.33 \times 10^{-4}$$

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

Ans:

$$[\text{H}^+] = 3 \times 10^{-3} \text{ M}$$

$$\text{pH} = -\log[\text{H}^+]$$

$$= -\log(3 \times 10^{-3})$$

$$= 2.523$$

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



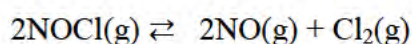
$$[\text{H}^+] = (2 \times 1 \times 10^{-2})$$

$$\text{pH} = -\log[\text{H}^+] = -\log(2 \times 10^{-2})$$

$$= 1.6989$$

Answer the questions. (4 Score each)

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



(b) Find the value of K_c for the above equilibrium if the value of K_p is $1.8 \times 10^{-2} \text{ atm}$ at 600 K?

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

Ans: (a)
$$K_p = \frac{(P_{\text{NO}})^2 \times (P_{\text{Cl}_2})}{(P_{\text{NOCl}})^2}$$

(b) Here $K_p = 1.8 \times 10^{-2}$, $R = 0.0821 \text{ atm/K/mol}$,

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

$$T = 600\text{K}$$

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

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

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

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

24. Derive the relation between K_p and K_c ?

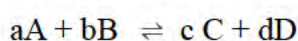
Ans: From Ideal gas equation $PV = nRT$

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

Here, $n/V = \text{Concentration in mol/m}^3$

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

Consider a general reaction,



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

Rearranging pressure in terms of CRT we get,

$$\begin{aligned} K_p &= \frac{[C]^c \times [D]^d \times (RT)^{(c+d)}}{[A]^a \times [B]^b \times (RT)^{(a+b)}} \\ &= \frac{[C]^c \times [D]^d}{[A]^a \times [B]^b} (RT)^{(c+d)-(a+b)} \\ &= \frac{[C]^c \times [D]^d}{[A]^a \times [B]^b} (RT)^{\Delta n} \\ &= K_c(RT)^{\Delta n} \end{aligned}$$

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

Here $\Delta n = (\text{number of moles of gaseous products}) - (\text{number of moles of gaseous reactants})$