# Chapter 7. Equilibrium

**1.** The equilibrium constants of the following are

$N_2 + 3H_2 \rightleftharpoons 2NH_3$; $K_1$

$N_2 + O_2 \rightleftharpoons 2NO$; $K_2$

$H_2 + \frac{1}{2}O_2 \rightleftharpoons H_2O$; $K_3$

The equilibrium constant ($K$) of the reaction :

$2NH_3 + \frac{5}{2}O_2 \overset{K}{\rightleftharpoons} 2NO + 3H_2O$ will be

(a) $K_2K_3^3/K_1$ (b) $K_2K_3/K_1$

(c) $K_2^3K_3/K_1$ (d) $K_1K_3^3/K_2$

*(NEET 2017, 2007, 2003)*

**2.** Concentration of the $Ag^+$ ions in a saturated solution of $Ag_2C_2O_4$ is $2.2 \times 10^{-4}$ mol $L^{-1}$. Solubility product of $Ag_2C_2O_4$ is

(a) $2.66 \times 10^{-12}$ (b) $4.5 \times 10^{-11}$

(c) $5.3 \times 10^{-12}$ (d) $2.42 \times 10^{-8}$

*(NEET 2017)*

**3.** A 20 litre container at 400 K contains $CO_{2(g)}$ at pressure 0.4 atm and an excess of SrO (neglect the volume of solid SrO). The volume of the container is now decreased by moving the movable piston fitted in the container. The maximum volume of the container, when pressure of $CO_2$ attains its maximum value, will be

(Given that : $SrCO_{3(s)} \rightleftharpoons SrO_{(s)} + CO_{2(g)}$, $K_p = 1.6$ atm)

(a) 10 litre (b) 4 litre

(c) 2 litre (d) 5 litre

*(NEET 2017)*

**4.** The percentage of pyridine ($C_5H_5N$) that forms pyridinium ion ($C_5H_5N^+H$) in a 0.10 M aqueous pyridine solution ($K_b$ for $C_5H_5N = 1.7 \times 10^{-9}$) is

(a) 0.0060% (b) 0.013%

(c) 0.77% (d) 1.6%

*(NEET-II 2016)*

**5.** The solubility of $AgCl_{(s)}$ with solubility product $1.6 \times 10^{-10}$ in 0.1 M NaCl solution would be

(a) $1.26 \times 10^{-5}$ M (b) $1.6 \times 10^{-9}$ M

(c) $1.6 \times 10^{-11}$ M (d) zero.

*(NEET-II 2016)*

**6.** Which of the following fluoro-compounds is most likely to behave as a Lewis base?

(a) $BF_3$ (b) $PF_3$ (c) $CF_4$ (d) $SiF_4$

*(NEET-II 2016)*

**7.** $MY$ and $NY_3$, two nearly insoluble salts, have the same $K_{sp}$ values of $6.2 \times 10^{-13}$ at room temperature. Which statement would be true in regard to $MY$ and $NY_3$?

(a) The salts $MY$ and $NY_3$ are more soluble in 0.5 M $KY$ than in pure water.

(b) The addition of the salt of $KY$ to solution of $MY$ and $NY_3$ will have no effect on their solubilities.

(c) The molar solubilities of $MY$ and $NY_3$ in water are identical.

(d) The molar solubility of $MY$ in water is less than that of $NY_3$. *(NEET-I 2016)*

**8.** If the equilibrium constant for

$N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$ is $K$, the equilibrium

constant for $\frac{1}{2}N_{2(g)} + \frac{1}{2}O_{2(g)} \rightleftharpoons NO_{(g)}$ will be

(a) $\frac{1}{2}K$ (b) $K$

(c) $K^2$ (d) $K^{1/2}$ *(2015)*

**9.** What is the pH of the resulting solution when equal volumes of 0.1 M NaOH and 0.01 M HCl are mixed?

(a) 2.0 (b) 7.0

(c) 1.04 (d) 12.65 *(2015)*

**10.** Aqueous solution of which of the following compounds is the best conductor of electric current?

(a) Hydrochloric acid, HCl

(b) Ammonia, $NH_3$

(c) Fructose, $C_6H_{12}O_6$

(d) Acetic acid, $C_2H_4O_2$ *(2015)*

**11.** Which one of the following pairs of solution is not an acidic buffer?
(a) $CH_3COOH$ and $CH_3COONa$
(b) $H_2CO_3$ and $Na_2CO_3$
(c) $H_3PO_4$ and $Na_3PO_4$
(d) $HClO_4$ and $NaClO_4$ *(2015)*

**12.** The $K_{sp}$ of $Ag_2CrO_4$, AgCl, AgBr and AgI are respectively, $1.1 \times 10^{-12}$, $1.8 \times 10^{-10}$, $5.0 \times 10^{-13}$, $8.3 \times 10^{-17}$. Which one of the following salts will precipitate last if $AgNO_3$ solution is added to the solution containing equal moles of NaCl, NaBr, NaI and $Na_2CrO_4$?
(a) AgBr
(b) $Ag_2CrO_4$
(c) AgI
(d) AgCl
*(2015, Cancelled)*

**13.** Which of the following statements is correct for a reversible process in a state of equilibrium?
(a) $\Delta G° = -2.30\, RT \log K$
(b) $\Delta G° = 2.30\, RT \log K$
(c) $\Delta G = -2.30\, RT \log K$
(d) $\Delta G = 2.30\, RT \log K$ *(2015, Cancelled)*

**14.** If the value of equilibrium constant for a particular reaction is $1.6 \times 10^{12}$, then at equilibrium the system will contain
(a) mostly products
(b) similar amounts of reactants and products
(c) all reactants
(d) mostly reactants. *(2015, Cancelled)*

**15.** Which of the following salts will give highest pH in water?
(a) KCl
(b) NaCl
(c) $Na_2CO_3$
(d) $CuSO_4$ *(2014)*

**16.** Using the Gibb's energy change, $\Delta G° = +63.3$ kJ, for the following reaction,

$$Ag_2CO_{3(s)} \rightleftharpoons 2Ag^+_{(aq)} + CO_3^{2-}{}_{(aq)}$$

the $K_{sp}$ of $Ag_2CO_{3(s)}$ in water at 25 °C is ($R = 8.314$ J $K^{-1}$ $mol^{-1}$)
(a) $3.2 \times 10^{-26}$
(b) $8.0 \times 10^{-12}$
(c) $2.9 \times 10^{-3}$
(d) $7.9 \times 10^{-2}$
*(2014)*

**17.** For the reversible reaction,
$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ + heat
The equilibrium shifts in forward direction
(a) by increasing the concentration of $NH_{3(g)}$
(b) by decreasing the pressure
(c) by decreasing the concentrations of $N_{2(g)}$ and $H_{2(g)}$
(d) by increasing pressure and decreasing temperature. *(2014)*

**18.** For a given exothermic reaction, $K_p$ and $K'_p$ are the equilibrium constants at temperatures $T_1$ and $T_2$, respectively. Assuming that heat of reaction is constant in temperature range between $T_1$ and $T_2$, it is readily observed that
(a) $K_p > K'_p$
(b) $K_p < K'_p$
(c) $K_p = K'_p$
(d) $K_p = \dfrac{1}{K'_p}$
*(2014)*

**19.** $KMnO_4$ can be prepared from $K_2MnO_4$ as per the reaction,

$$3MnO_4^{2-} + 2H_2O \rightleftharpoons 2MnO_4^{\;-} + MnO_2 + 4OH^-$$

The reaction can go to completion by removing $OH^-$ ions by adding
(a) $CO_2$
(b) $SO_2$
(c) HCl
(d) KOH
*(NEET 2013)*

**20.** Which of these is least likely to act as a Lewis base?
(a) $BF_3$
(b) $PF_3$
(c) CO
(d) $F^-$
*(NEET 2013)*

**21.** Accumulation of lactic acid ($HC_3H_5O_3$), a monobasic acid in tissues leads to pain and a feeling of fatigue. In a 0.10 M aqueous solution, lactic acid is 3.7% dissociates. The value of dissociation constant, $K_a$, for this acid will be
(a) $1.4 \times 10^{-5}$
(b) $1.4 \times 10^{-4}$
(c) $3.7 \times 10^{-4}$
(d) $2.8 \times 10^{-4}$
*(Karnataka NEET 2013)*

**22.** At 100°C the $K_w$ of water is 55 times its value at 25°C. What will be the pH of neutral solution? (log 55 = 1.74)
(a) 7.00
(b) 7.87
(c) 5.13
(d) 6.13
*(Karnataka NEET 2013)*

**23.** The values of $K_{sp}$ of $CaCO_3$ and $CaC_2O_4$ are $4.7 \times 10^{-9}$ and $1.3 \times 10^{-9}$ respectively at 25°C. If the mixture of these two is washed with water, what is the concentration of $Ca^{2+}$ ions in water?
(a) $5.831 \times 10^{-5}$ M
(b) $6.856 \times 10^{-5}$ M
(c) $3.606 \times 10^{-5}$ M
(d) $7.746 \times 10^{-5}$ M
*(Karnataka NEET 2013)*

**24.** The dissociation constant of a weak acid is $1 \times 10^{-4}$. In order to prepare a buffer solution with a pH = 5, the [Salt]/[Acid] ratio should be

(a) 4 : 5 (b) 10 : 1 (c) 5 : 4 (d) 1 : 10

*(Karnataka NEET 2013)*

**25.** pH of a saturated solution of $Ba(OH)_2$ is 12. The value of solubility product ($K_{sp}$) of $Ba(OH)_2$ is

(a) $3.3 \times 10^{-7}$ (b) $5.0 \times 10^{-7}$

(c) $4.0 \times 10^{-6}$ (d) $5.0 \times 10^{-6}$

*(2012)*

**26.** Equimolar solutions of the following substances were prepared separately. Which one of these will record the highest pH value?

(a) $BaCl_2$ (b) $AlCl_3$ (c) LiCl (d) $BeCl_2$

*(2012)*

**27.** Buffer solutions have constant acidity and alkalinity because

(a) these give unionised acid or base on reaction with added acid or alkali

(b) acids and alkalies in these solutions are shielded from attack by other ions

(c) they have large excess of $H^+$ or $OH^-$ ions

(d) they have fixed value of pH. *(2012)*

**28.** Given that the equilibrium constant for the reaction,

$$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$$

has a value of 278 at a particular temperature. What is the value of the equilibrium constant for the following reaction at the same temperature?

$$SO_{3(g)} \rightleftharpoons SO_{2(g)} + \frac{1}{2}O_{2(g)}$$

(a) $1.8 \times 10^{-3}$ (b) $3.6 \times 10^{-3}$

(c) $6.0 \times 10^{-2}$ (d) $1.3 \times 10^{-5}$

*(Mains 2012)*

**29.** Given the reaction between 2 gases represented by $A_2$ and $B_2$ to give the compound $AB_{(g)}$.

$$A_{2(g)} + B_{2(g)} \rightleftharpoons 2AB_{(g)}$$

At equilibrium, the concentration of $A_2 = 3.0 \times 10^{-3}$ M, of $B_2 = 4.2 \times 10^{-3}$ M, of $AB = 2.8 \times 10^{-3}$ M

If the reaction takes place in a sealed vessel at 527°C, then the value of $K_c$ will be

(a) 2.0 (b) 1.9 (c) 0.62 (d) 4.5

*(Mains 2012)*

**30.** The value of $\Delta H$ for the reaction $X_{2(g)} + 4Y_{2(g)} \rightleftharpoons 2XY_{4(g)}$ is less than zero. Formation of $XY_{4(g)}$ will be favoured at

(a) high temperature and high pressure

(b) low pressure and low temperature

(c) high temperature and low pressure

(d) high pressure and low temperature

*(2011)*

**31.** A buffer solution is prepared in which the concentration of $NH_3$ is 0.30 M and the concentration of $NH_4^+$ is 0.20 M. If the equilibrium constant, $K_b$ for $NH_3$ equals $1.8 \times 10^{-5}$, what is the pH of this solution? (log 2.7 = 0.43)

(a) 9.08 (b) 9.43 (c) 11.72 (d) 8.73

*(2011)*

**32.** Which of the following is least likely to behave as Lewis base?

(a) $H_2O$ (b) $NH_3$ (c) $BF_3$ (d) $OH^-$

*(2011)*

**33.** For the reaction, $N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$, the equilibrium constant is $K_1$. The equilibrium constant is $K_2$ for the reaction,

$2NO_{(g)} + O_{2(g)} \rightleftharpoons 2NO_{2(g)}$

What is $K$ for the reaction,

$$NO_{2(g)} \rightleftharpoons \frac{1}{2}N_{2(g)} + O_{2(g)}$$

(a) $\dfrac{1}{2K_1K_2}$ (b) $\dfrac{1}{4K_1K_2}$

(c) $\left[\dfrac{1}{K_1K_2}\right]^{1/2}$ (d) $\dfrac{1}{K_1K_2}$ *(2011)*

**34.** In qualitative analysis, the metals of group I can be separated from other ions by precipitating them as chloride salts. A solution initially contains $Ag^+$ and $Pb^{2+}$ at a concentration of 0.10 M. Aqueous HCl is added to this solution until the $Cl^-$ concentration is 0.10 M. What will the concentrations of $Ag^+$ and $Pb^{2+}$ be at equilibrium?

($K_{sp}$ for AgCl = $1.8 \times 10^{-10}$, $K_{sp}$ for $PbCl_2$ = $1.7 \times 10^{-5}$)

(a) $[Ag^+] = 1.8 \times 10^{-7}$ M, $[Pb^{2+}] = 1.7 \times 10^{-6}$ M

(b) $[Ag^+] = 1.8 \times 10^{-11}$ M, $[Pb^{2+}] = 8.5 \times 10^{-5}$ M

(c) $[Ag^+] = 1.8 \times 10^{-9}$ M, $[Pb^{2+}] = 1.7 \times 10^{-3}$ M

(d) $[Ag^+] = 1.8 \times 10^{-11}$ M, $[Pb^{2+}] = 1.7 \times 10^{-4}$ M

*(Mains 2011)*

**35.** If pH of a saturated solution of $Ba(OH)_2$ is 12, the value of its $K_{sp}$ is

(a) $4.00 \times 10^{-6}$ $M^3$ (b) $4.00 \times 10^{-7}$ $M^3$

(c) $5.00 \times 10^{-6}$ $M^3$ (d) $5.00 \times 10^{-7}$ $M^3$

*(2010)*

**36.** What is [$H^+$] in mol/L of a solution that is 0.20 M in $CH_3COONa$ and 0.10 M in $CH_3COOH$? $K_a$ for $CH_3COOH = 1.8 \times 10^{-5}$

(a) $3.5 \times 10^{-4}$ (b) $1.1 \times 10^{-5}$
(c) $1.8 \times 10^{-5}$ (d) $9.0 \times 10^{-6}$

*(2010)*

**37.** In which of the following equilibrium $K_c$ and $K_p$ are not equal?

(a) $2NO_{(g)} \rightleftharpoons N_{2(g)} + O_{2(g)}$
(b) $SO_{2(g)} + NO_{2(g)} \rightleftharpoons SO_{3(g)} + NO_{(g)}$
(c) $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$
(d) $2C_{(s)} + O_{2(g)} \rightleftharpoons 2CO_{2(g)}$ *(2010)*

**38.** In a buffer solution containing equal concentration of $B^-$ and $HB$, the $K_b$ for $B^-$ is $10^{-10}$. The pH of buffer solution is

(a) 10 (b) 7 (c) 6 (d) 4

*(2010)*

**39.** The reaction,

$2A_{(g)} + B_{(g)} \rightleftharpoons 3C_{(g)} + D_{(g)}$

is begun with the concentrations of $A$ and $B$ both at an initial value of 1.00 M. When equilibrium is reached, the concentration of $D$ is measured and found to be 0.25 M. The value for the equilibrium constant for this reaction is given by the expression

(a) $[(0.75)^3(0.25)] \div [(1.00)^2(1.00)]$
(b) $[(0.75)^3(0.25)] \div [(0.50)^2(0.75)]$
(c) $[(0.75)^3(0.25)] \div [(0.50)^2(0.25)]$
(d) $[(0.75)^3(0.25)] \div [(0.75)^2(0.25)]$

*(Mains 2010)*

**40.** The dissociation constants for acetic acid and HCN at 25°C are $1.5 \times 10^{-5}$ and $4.5 \times 10^{-10}$ respectively. The equilibrium constant for the equilibrium

$CN^- + CH_3COOH \rightleftharpoons HCN + CH_3COO^-$

would be

(a) $3.0 \times 10^{-5}$ (b) $3.0 \times 10^{-4}$
(c) $3.0 \times 10^{4}$ (d) $3.0 \times 10^{5}$ (2009)

**41.** Which of the following molecules acts as a Lewis acid?

(a) $(CH_3)_2O$ (b) $(CH_3)_3P$
(c) $(CH_3)_3N$ (d) $(CH_3)_3B$ *(2009)*

**42.** The ionization constant of ammonium hydroxide is $1.77 \times 10^{-5}$ at 298 K. Hydrolysis constant of ammonium chloride is

(a) $6.50 \times 10^{-12}$ (b) $5.65 \times 10^{-13}$
(c) $5.65 \times 10^{-12}$ (d) $5.65 \times 10^{-10}$

*(2009)*

**43.** What is the [$OH^-$] in the final solution prepared by mixing 20.0 mL of 0.050 M HCl with 30.0 mL of 0.10 M $Ba(OH)_2$?

(a) 0.40 M (b) 0.0050 M
(c) 0.12 M (d) 0.10 M *(2009)*

**44.** The dissociation equilibrium of a gas $AB_2$ can be represented as :

$2AB_{2\,(g)} \rightleftharpoons 2AB_{\,(g)} + B_{2(g)}$

The degree of dissociation is $x$ and is small compared to 1. The expression relating the degree of dissociation ($x$) with equilibrium constant $K_P$ and total pressure $P$ is

(a) $(2K_P/P)^{1/2}$ (b) $(K_P/P)$
(c) $(2K_P/P)$ (d) $(2K_P/P)^{1/3}$

*(2008)*

**45.** If the concentration of $OH^-$ ions in the reaction

$Fe(OH)_{3(s)} \rightleftharpoons Fe^{3+}{}_{(aq)} + 3OH^-{}_{(aq)}$

is decreased by 1/4 times, then equilibrium concentration of $Fe^{3+}$ will increase by

(a) 64 times (b) 4 times
(c) 8 times (d) 16 times *(2008)*

**46.** Equal volumes of three acid solutions of pH 3, 4 and 5 are mixed in a vessel. What will be the $H^+$ ion concentration in the mixture?

(a) $3.7 \times 10^{-3}$ M (b) $1.11 \times 10^{-3}$ M
(c) $1.11 \times 10^{-4}$ M (d) $3.7 \times 10^{-4}$ M

*(2008)*

**47.** The value of equilibrium constant of the reaction

$$HI_{(g)} \rightleftharpoons \frac{1}{2}H_{2\,(g)} + \frac{1}{2}I_{2(g)}$$

is 8.0. The equilibrium constant of the reaction $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$ will be

(a) 16 (b) 1/8 (c) 1/16 (d) 1/64

*(2008)*

**48.** The values of  for the reactions,

$X \rightleftharpoons Y + Z$ ...(i)
$A \rightleftharpoons 2B$ ...(ii)

are in the ratio 9 : 1. If degree of dissociation of $X$ and $A$ be equal, then total pressure at equilibrium (i) and (ii) are in the ratio

(a) 36 : 1 (b) 1 : 1 (c) 3 : 1 (d) 1 : 9

*(2008)*

**49.** A weak acid, $HA$, has a $K_a$ of $1.00 \times 10^{-5}$. If 0.100 mol of this acid is dissolved in one litre of water, the percentage of acid dissociated at equilibrium is closest to

(a) 1.00% (b) 99.9%
(c) 0.100% (d) 99.0% *(2007)*

**50.** Calculate the pOH of a solution at 25°C that contains $1 \times 10^{-10}$ M of hydronium ions, *i.e.* $H_3O^+$.
(a) 4.000 (b) 9.000 (c) 1.000 (d) 7.000 *(2007)*

**51.** For the reaction:
$CH_{4(g)} + 2O_{2(g)} \rightleftharpoons CO_{2(g)} + 2H_2O_{(l)}$,
$\Delta H_r = -170.8$ kJ mol$^{-1}$. Which of the following statements is not true?
(a) The reaction is exothermic.
(b) At equilibrium, the concentrations of $CO_{2(g)}$ and $H_2O_{(l)}$ are not equal.
(c) The equilibrium constant for the reaction is given by $K_p = \dfrac{[CO_2]}{[CH_4][O_2]}$.
(d) Addition of $CH_{4(g)}$ or $O_{2(g)}$ at equilibrium will cause a shift to the right. *(2006)*

**52.** Which of the following pairs constitutes a buffer?
(a) HCl and KCl
(b) $HNO_2$ and $NaNO_2$
(c) NaOH and NaCl
(d) $HNO_3$ and $NH_4NO_3$ *(2006)*

**53.** The hydrogen ion concentration of a $10^{-8}$ M HCl aqueous solution at 298 K ($K_w = 10^{-14}$) is
(a) $1.0 \times 10^{-8}$ M (b) $1.0 \times 10^{-6}$ M
(c) $1.0525 \times 10^{-7}$ M (d) $9.525 \times 10^{-8}$ M *(2006)*

**54.** At 25°C, the dissociation constant of a base, *B*OH, is $1.0 \times 10^{-12}$. The concentration of hydroxyl ions in 0.01 M aqueous solution of the base would be
(a) $1.0 \times 10^{-5}$ mol L$^{-1}$ (b) $1.0 \times 10^{-6}$ mol L$^{-1}$
(c) $2.0 \times 10^{-6}$ mol L$^{-1}$ (d) $1.0 \times 10^{-7}$ mol L$^{-1}$ *(2005)*

**55.** $H_2S$ gas when passed through a solution of cations containing HCl precipitates the cations of second group of qualitative analysis but not those belonging to the fourth group. It is because
(a) presence of HCl decreases the sulphide ion concentration
(b) solubility product of group II sulphides is more than that of group IV sulphides
(c) presence of HCl increases the sulphide ion concentration
(d) sulphides of group IV cations are unstable in HCl. *(2005)*

**56.** Equilibrium constants $K_1$ and $K_2$ for the following equilibria:

$NO_{(g)} + \frac{1}{2}O_2 \underset{}{\overset{K_1}{\rightleftharpoons}} NO_{2(g)}$ and

$2NO_{2(g)} \overset{K_2}{\rightleftharpoons} 2NO_{(g)} + O_{2(g)}$ are related as
(a) $K_2 = 1/K_1^2$ (b) $K_2 = K_1^2$
(c) $K_2 = 1/K_1$ (d) $K_2 = K_1/2$ *(2005)*

**57.** The solubility product of a sparingly soluble salt $AX_2$ is $3.2 \times 10^{-11}$. Its solubility (in moles/L) is
(a) $5.6 \times 10^{-6}$ (b) $3.1 \times 10^{-4}$
(c) $2 \times 10^{-4}$ (d) $4 \times 10^{-4}$ *(2004)*

**58.** The rapid change of pH near the stoichiometric point of an acid-base titration is the basis of indicator detection. pH of the solution is related to ratio of the concentrations of the conjugate acid (HIn) and base ($In^-$) forms of the indicator by the expression

(a) $\log\dfrac{[In^-]}{[HIn]} = pK_{In} - pH$

(b) $\log\dfrac{[HIn]}{[In^-]} = pK_{In} - pH$

(c) $\log\dfrac{[HIn]}{[In^-]} = pH - pK_{In}$

(d) $\log\dfrac{[In^-]}{[HIn]} = pH - pK_{In}$ *(2004)*

**59.** In Haber process 30 litres of dihydrogen and 30 litres of dinitrogen were taken for reaction which yielded only 50 % of the expected product. What will be the composition of gaseous mixture under the aforesaid condition in the end?
(a) 20 litres ammonia, 20 litres nitrogen, 20 litres hydrogen
(b) 10 litres ammonia, 25 litres nitrogen, 15 litres hydrogen
(c) 20 litres ammonia, 10 litres nitrogen, 30 litres hydrogen
(d) 20 litres ammonia, 25 litres nitrogen, 15 litres hydrogen *(2003)*

**60.** The reaction quotient (*Q*) for the reaction $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ is given by $Q = \dfrac{[NH_3]^2}{[N_2][H_2]^3}$. The reaction will proceed from right to left if
(a) $Q = K_c$ (b) $Q < K_c$
(c) $Q > K_c$ (d) $Q = 0$
where $K_c$ is the equilibrium constant. *(2003)*

**61.** Which one of the following statements is not true?
(a) Among halide ions, iodide is the most powerful reducing agent.
(b) Fluorine is the only halogen that does not show a variable oxidation state.
(c) HOCl is a stronger acid than HOBr.
(d) HF is a stronger acid than HCl. *(2003)*

**62.** The solubility product of AgI at 25°C is $1.0 \times 10^{-16}$ mol$^2$ L$^{-2}$. The solubility of AgI in $10^{-4}$ N solution of KI at 25°C is approximately (in mol L$^{-1}$)
(a) $1.0 \times 10^{-16}$
(b) $1.0 \times 10^{-12}$
(c) $1.0 \times 10^{-10}$
(d) $1.0 \times 10^{-8}$
*(2003)*

**63.** Reaction $BaO_{2(s)} \rightleftharpoons BaO_{(s)} + O_{2(g)}$; $\Delta H$ = +ve. In equilibrium condition, pressure of $O_2$ depends on
(a) increase mass of $BaO_2$
(b) increase mass of BaO
(c) increase temperature on equilibrium
(d) increase mass of $BaO_2$ and BaO both.
*(2002)*

**64.** Solubility of $MX_2$ type electrolytes is $0.5 \times 10^{-4}$ mole/lit., then find out $K_{sp}$ of electrolytes.
(a) $5 \times 10^{-12}$
(b) $25 \times 10^{-10}$
(c) $1 \times 10^{-13}$
(d) $5 \times 10^{-13}$ *(2002)*

**65.** Which has highest pH?
(a) $CH_3COOK$
(b) $Na_2CO_3$
(c) $NH_4Cl$
(d) $NaNO_3$ *(2002)*

**66.** Solution of 0.1 N $NH_4OH$ and 0.1 N $NH_4Cl$ has pH 9.25. Then find out $pK_b$ of $NH_4OH$.
(a) 9.25
(b) 4.75
(c) 3.75
(d) 8.25
*(2002)*

**67.** In $HS^-$, $I^-$, $R - NH_2$, $NH_3$ order of proton accepting tendency will be
(a) $I^- > NH_3 > R - NH_2 > HS^-$
(b) $NH_3 > R - NH_2 > HS^- > I^-$
(c) $R - NH_2 > NH_3 > HS^- > I^-$
(d) $HS^- > R - NH_2 > NH_3 > I^-$ *(2001)*

**68.** Ionisation constant of $CH_3COOH$ is $1.7\times10^{-5}$ and concentration of $H^+$ ions is $3.4 \times 10^{-4}$. Then find out initial concentration of $CH_3COOH$ molecules.
(a) $3.4 \times 10^{-4}$
(b) $3.4 \times 10^{-3}$
(c) $6.8 \times 10^{-4}$
(d) $6.8 \times 10^{-3}$
*(2001)*

**69.** Solubility of $M_2S$ salt is $3.5 \times 10^{-6}$ then find out solubility product.
(a) $1.7 \times 10^{-6}$
(b) $1.7 \times 10^{-16}$
(c) $1.7 \times 10^{-18}$
(d) $1.7 \times 10^{-12}$
*(2001)*

**70.** Correct relation between dissociation constants of a dibasic acid is
(a) $K_{a_1} = K_{a_2}$
(b) $K_{a_1} > K_{a_2}$
(c) $K_{a_1} < K_{a_2}$
(d) $K_{a_1} = \frac{1}{K_{a_2}}$
*(2000)*

**71.** For any reversible reaction, if we increase concentration of the reactants, then effect on equilibrium constant
(a) depends on amount of concentration
(b) unchange
(c) decrease
(d) increase. *(2000)*

**72.** Conjugate acid of $NH_2^-$ is
(a) $NH_4OH$
(b) $NH_4^+$
(c) $NH_2^-$
(d) $NH_3$ *(2000)*

**73.** Which statement is wrong about pH and $H^+$?
(a) pH of neutral water is not zero.
(b) Adding 1 N solution of $CH_3COOH$ and 1 N solution of NaOH, pH will be seven.
(c) $[H^+]$ of dilute and hot $H_2SO_4$ is more than concentrated and cold $H_2SO_4$.
(d) Mixing solution of $CH_3COOH$ and HCl, pH will be less than 7. *(2000)*

**74.** Equilibrium constant $K_p$ for following reaction
$MgCO_{3(s)} \rightleftharpoons MgO_{(s)} + CO_{2(g)}$
(a) $K_p = P_{CO_2}$
(b) $K_p = P_{CO_2} \times \frac{P_{CO_2} \times P_{MgO}}{P_{MgCO_3}}$
(c) $K_p = \frac{P_{CO_2} + P_{MgO}}{P_{MgCO_3}}$
(d) $K_p = \frac{P_{MgCO_3}}{P_{CO_2} \times P_{MgO}}$ *(2000)*

**75.** The strongest conjugate base is
(a) $SO_4^{2-}$
(b) $Cl^-$
(c) $NO_3^-$
(d) $CH_3COO^-$
*(1999)*

**76.** The concentration of $[H^+]$ and concentration of $[OH^-]$ of a 0.1 aqueous solution of 2% ionised weak acid is [ionic product of water = $1 \times 10^{-14}$]
(a) $2 \times 10^{-3}$ M and $5 \times 10^{-12}$ M

(b) $1 \times 10^{-3}$ M and $3 \times 10^{-11}$ M
(c) $0.02 \times 10^{-3}$ M and $5 \times 10^{-11}$ M
(d) $3 \times 10^{-2}$ M and $4 \times 10^{-13}$ M *(1999)*

**77.** The solubility of a saturated solution of calcium fluoride is $2 \times 10^{-4}$ moles per litre. Its solubility product is
(a) $22 \times 10^{-11}$ (b) $14 \times 10^{-4}$
(c) $2 \times 10^{-2}$ (d) $32 \times 10^{-12}$ *(1999)*

**78.** If $K_1$ and $K_2$ are the respective equilibrium constants for the two reactions,
$XeF_{6(g)} + H_2O_{(g)} \rightarrow XeOF_{4(g)} + 2HF_{(g)}$
$XeO_{4(g)} + XeF_{6(g)} \rightarrow XeOF_{4(g)} + XeO_3F_{2(g)}$,
the equilibrium constant of the reaction,
$XeO_{4(g)} + 2HF_{(g)} \rightarrow XeO_3F_{2(g)} + H_2O_{(g)}$,
will be
(a) $K_1/K_2$ (b) $K_1 \cdot K_2$
(c) $K_1/(K_2)^2$ (d) $K_2/K_1$ *(1998)*

**79.** A physician wishes to prepare a buffer solution at pH = 3.85 that efficiently resists changes in pH yet contains only small concentration of the buffering agents. Which of the following weak acids together with its sodium salt would be best to use?
(a) 2, 5-Dihydroxy benzoic acid (p$K_a$ = 2.97)
(b) Acetoacetic acid (p$K_a$ = 3.58)
(c) *m*-Chlorobenzoic acid (p$K_a$ = 3.98)
(d) *p*-Chlorocinnamic acid (p$K_a$ = 4.41) *(1997)*

**80.** The hydride ion $H^-$ is stronger base than its hydroxide ion $OH^-$. Which of the following reaction will occur if sodium hydride (NaH) is dissolved in water?
(a) $H^- + H_2O \rightarrow$ no reaction
(b) $H^-_{(aq)} + H_2O \rightarrow H_2O$
(c) $H^-_{(aq)} + H_2O_{(l)} \rightarrow OH^- + H_2$
(d) None of these. *(1997)*

**81.** The solubility product of CuS, $Ag_2S$ and HgS are $10^{-31}$, $10^{-44}$ and $10^{-54}$ respectively. The solubilities of these sulphides are in the order
(a) HgS > $Ag_2S$ > CuS
(b) CuS > $Ag_2S$ > HgS
(c) $Ag_2S$ > CuS > HgS
(d) AgS > HgS > CuS *(1997)*

**82.** The equilibrium constant for the reaction $N_2 + 3H_2 \rightleftharpoons 2NH_3$ is $K$, then the equilibrium constant for the equilibrium $2NH_3 \rightleftharpoons N_2 + 3H_2$ is
(a) $\sqrt{K}$ (b) $\sqrt{\frac{1}{K}}$ (c) $\frac{1}{K}$ (d) $\frac{1}{K^2}$ *(1996)*

**83.** The ionic product of water at 25°C is $10^{-14}$. Its ionic product at 90°C will be,
(a) $1 \times 10^{-14}$ (b) $1 \times 10^{-16}$
(c) $1 \times 10^{-20}$ (d) $1 \times 10^{-12}$ *(1996)*

**84.** If $\alpha$ is dissociation constant, then the total number of moles for the reaction,
$2HI \rightarrow H_2 + I_2$ will be
(a) 1 (b) $1 - \alpha$
(c) 2 (d) $2 - \alpha$ *(1996)*

**85.** The pH value of $N$/10 NaOH solution is
(a) 12 (b) 13 (c) 10 (d) 11 *(1996)*

**86.** Which of the following is not a Lewis acid?
(a) $SiF_4$ (b) $C_2H_4$ (c) $BF_3$ (d) $FeCl_3$ *(1996)*

**87.** The pH value of blood does not appreciably change by a small addition of an acid or a base, because the blood
(a) can be easily coagulated
(b) contains iron as a part of the molecule
(c) is a body fluid
(d) contains serum protein which acts as buffer. *(1995)*

**88.** The pH value of a 10 M solution of HCl is
(a) equal to 1 (b) equal to 2
(c) less than 0 (d) equal to 0 *(1995)*

**89.** The solubility of AgCl will be minimum in
(a) 0.01 M $CaCl_2$ (b) pure water
(c) 0.001 M $AgNO_3$ (d) 0.01 M NaCl *(1995)*

**90.** In liquid-gas equilibrium, the pressure of vapours above the liquid is constant at
(a) constant temperature
(b) low temperature
(c) high temperature
(d) none of these. *(1995)*

**91.** Which one of the following is most soluble?
(a) $Bi_2S_3$ ($K_{sp} = 1 \times 10^{-70}$)
(b) $Ag_2S$ ($K_{sp} = 6 \times 10^{-51}$)
(c) CuS ($K_{sp} = 8 \times 10^{-37}$)
(d) MnS ($K_{sp} = 7 \times 10^{-16}$) *(1994)*

**92.** At 80°C, distilled water has $[H_3O^+]$ concentration equal to $1 \times 10^{-6}$ mole/litre. The value of $K_w$ at this temperature will be

(a) $1 \times 10^{-12}$ (b) $1 \times 10^{-15}$
(c) $1 \times 10^{-6}$ (d) $1 \times 10^{-9}$ *(1994)*

**93.** According to Le Chatelier's principle, adding heat to a solid and liquid in equilibrium will cause the

(a) temperature to increase
(b) temperature to decrease
(c) amount of liquid to decrease
(d) amount of solid to decrease. *(1993)*

**94.** 0.1 M solution of which one of these substances will act basic?

(a) Sodium borate
(b) Ammonium chloride
(c) Calcium nitrate
(d) Sodium sulphate *(1992)*

**95.** Which one of the following information can be obtained on the basis of Le Chatelier principle?

(a) Dissociation constant of a weak acid
(b) Entropy change in a reaction
(c) Equilibrium constant of a chemical reaction
(d) Shift in equilibrium position on changing value of a constraint. *(1992)*

**96.** Aqueous solution of acetic acid contains

(a) $CH_3COO^-$ and $H^+$
(b) $CH_3COO^-$, $H_3O^+$ and $CH_3COOH$
(c) $CH_3COO^-$, $H_3O^+$ and $H^+$
(d) $CH_3COOH$, $CH_3COO^-$ and $H^+$ *(1991)*

**97.** $K_1$ and $K_2$ are equilibrium constant for reactions (i) and (ii)

$$N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)} \quad \text{....(i)}$$

$$NO_{(g)} \rightleftharpoons \frac{1}{2}N_{2(g)} + \frac{1}{2}O_{2(g)} \quad \text{...(ii)}$$

(a) $K_1 = \left(\frac{1}{K_2}\right)^2$ (b) $K_1 = K_2^2$
(c) $K_1 = \frac{1}{K_2}$ (d) $K_1 = (K_2)^0$
*(1989)*

**98.** The compound whose water solution has the highest pH is

(a) $NaCl$ (b) $NaHCO_3$
(c) $Na_2CO_3$ (d) $NH_4Cl$ *(1988)*

## Answer Key

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.** | (a) | **2.** | (c) | **3.** | (d) | **4.** | (b) | **5.** | (b) | **6.** | (b) | **7.** | (d) | **8.** | (d) | **9.** | (d) | **10.** | (a) |
| **11.** | (d) | **12.** | (b) | **13.** | (a) | **14.** | (a) | **15.** | (c) | **16.** | (b) | **17.** | (d) | **18.** | (a) | **19.** | (a) | **20.** | (a) |
| **21.** | (b) | **22.** | (d) | **23.** | (d) | **24.** | (b) | **25.** | (b) | **26.** | (a) | **27.** | (a) | **28.** | (c) | **29.** | (c) | **30.** | (d) |
| **31.** | (b) | **32.** | (c) | **33.** | (c) | **34.** | (c) | **35.** | (d) | **36.** | (d) | **37.** | (d) | **38.** | (d) | **39.** | (b) | **40.** | (c) |
| **41.** | (d) | **42.** | (d) | **43.** | (d) | **44.** | (d) | **45.** | (a) | **46.** | (d) | **47.** | (d) | **48.** | (a) | **49.** | (a) | **50.** | (a) |
| **51.** | (c) | **52.** | (b) | **53.** | (c) | **54.** | (d) | **55.** | (a) | **56.** | (a) | **57.** | (c) | **58.** | (d) | **59.** | (b) | **60.** | (c) |
| **61.** | (d) | **62.** | (b) | **63.** | (c) | **64.** | (d) | **65.** | (b) | **66.** | (b) | **67.** | (c) | **68.** | (d) | **69.** | (b) | **70.** | (b) |
| **71.** | (b) | **72.** | (d) | **73.** | (b) | **74.** | (a) | **75.** | (d) | **76.** | (a) | **77.** | (d) | **78.** | (d) | **79.** | (b) | **80.** | (d) |
| **81.** | (b) | **82.** | (c) | **83.** | (d) | **84.** | (c) | **85.** | (b) | **86.** | (b) | **87.** | (d) | **88.** | (c) | **89.** | (a) | **90.** | (a) |
| **91.** | (d) | **92.** | (a) | **93.** | (d) | **94.** | (a) | **95.** | (d) | **96.** | (b) | **97.** | (a) | **98.** | (c) | | | | |

# EXPLANATIONS

**1.** **(a) :** From the given equations,

$2NH_3 \rightleftharpoons N_2 + 3H_2;\ \dfrac{1}{K_1}$ ...(i)

$N_2 + O_2 \rightleftharpoons 2NO;\ K_2$ ...(ii)

$3H_2 + \dfrac{3}{2}O_2 \rightarrow 3H_2O;\ K_3^3$ ...(iii)

By adding equations (i), (ii) and (iii), we get

$$2NH_3 + \frac{5}{2}O_2 \overset{K}{\rightleftharpoons} 2NO + 3H_2O,\ K = \frac{K_2K_3^3}{K_1}$$

**2.** **(c) :** Let solubility of $Ag_2C_2O_4$ be $s$ mol $L^{-1}$

$$\underset{s}{Ag_2C_2O_{4(s)}} \rightleftharpoons \underset{2s}{2Ag^+_{(aq)}} + \underset{s}{C_2O_4^{2-}{}_{(aq)}}$$

$K_{sp} = (2s)^2(s) \Rightarrow 4s^3$

$K_{sp} = 4 \times (1.1 \times 10^{-4})^3$ ($\because [Ag^+] = 2s = 2.2 \times 10^{-4}$)

$K_{sp} \approx 5.3 \times 10^{-12}$

**3.** **(d) :** $SrCO_{3(s)} \rightleftharpoons SrO_{(s)} + CO_{2(g)};\ K_p = 1.6$ atm

$$K_p = \frac{p_{CO_2} \times p_{SrO}}{p_{SrCO_3}}$$

$\Rightarrow\ 1.6 = p_{CO_2}$ ($\because p_{SrO} = p_{SrCO_3} = 1$)

$\therefore$ Maximum pressure of $CO_2 = 1.6$ atm

Let the maximum volume of the container when pressure of $CO_2$ is 1.6 atm be $V$ L

During the process, $PV$ = constant

$\therefore\ 0.4 \times 20 = 1.6 \times V$

$$\Rightarrow\ V = \frac{0.4 \times 20}{1.6} = 5\text{ L}$$

**4.** **(b) :** $\underset{0.10\text{ M}}{C_5H_5N} + H_2O \rightleftharpoons C_5H_5\overset{+}{N}H + OH^-$

$$\alpha = \sqrt{\frac{K_b}{C}} = \sqrt{\frac{1.7 \times 10^{-9}}{0.10}} = 1.30 \times 10^{-4}$$

$\therefore$ Percentage of pyridine that forms pyridinium ion $= 1.30 \times 10^{-4} \times 100 = 0.013\%$

**5.** **(b) :** Let $s$ be the solubility of AgCl in moles per litre.

$$\underset{s}{AgCl_{(aq)}} \rightleftharpoons \underset{s}{Ag^+_{(aq)}} + \underset{(s+0.1)}{Cl^-_{(aq)}}$$

($\because$ 0.1 M NaCl solution also provides 0.1 M $Cl^-$ ion)

$K_{sp} = [Ag^+][Cl^-];\ 1.6 \times 10^{-10} = s(s + 0.1)$

$1.6 \times 10^{-10} = s(0.1)$ ($\because s <<<< 0.1$)

$$s = \frac{1.6 \times 10^{-10}}{0.1} = 1.6 \times 10^{-9}\text{ M}$$

**6.** **(b) :** $BF_3 \longrightarrow$ Lewis acid (incomplete octet)

$PF_3 \longrightarrow$ Lewis base (presence of lone pair on P atom)

$CF_4 \longrightarrow$ Complete octet

$SiF_4 \longrightarrow$ Lewis acid (empty *d*-orbital in Si-atom)

**7.** **(d) :** For $MY : K_{sp} = s_1^2$

$\Rightarrow s_1 = \sqrt{K_{sp}} = \sqrt{6.2 \times 10^{-13}} = 7.87 \times 10^{-7}$ mol $L^{-1}$

For $NY_3 : K_{sp} = 27s_2^4$

$$\Rightarrow\ s_2 = \sqrt[4]{\frac{6.2 \times 10^{-13}}{27}} = 3.89 \times 10^{-4}\text{ mol L}^{-1}$$

Hence, molar solubility of $MY$ in water is less than that of $NY_3$.

**8.** **(d) :** If the reaction is multiplied by $\frac{1}{2}$, then new equilibrium constant, $K' = K^{1/2}$.

**9.** **(d) :** One mole of NaOH is completely neutralised by one mole of HCl.

Hence, 0.01 mole of NaOH will be completely neutralised by 0.01 mole of HCl.

$\Rightarrow$ NaOH left unneutralised $= 0.1 - 0.01 = 0.09$ mol

As equal volumes of two solutions are mixed,

$$[OH]^- = \frac{0.09}{2} = 0.045\text{ M}$$

$\Rightarrow$ pOH $= -\log(0.045) = 1.35$

$\therefore$ pH $= 14 - 1.35 = 12.65$

**10.** **(a) :** HCl is a strong acid and dissociates completely into ions in aqueous solution.

**11.** **(d) :** Acidic buffer is a mixture of a weak acid and its salt with a strong base. $HClO_4$ is a strong acid.

**12.** **(b) :**

| **Salt** | $K_{sp}$ | **Solubility** |
|---|---|---|
| $Ag_2CrO_4$ | $1.1 \times 10^{-12} = 4s^3$ | $s = \sqrt[3]{\frac{K_{sp}}{4}} = 0.65 \times 10^{-4}$ |
| AgCl | $1.8 \times 10^{-10} = s^2$ | $s = \sqrt{K_{sp}} = 1.34 \times 10^{-5}$ |
| AgBr | $5 \times 10^{-13} = s^2$ | $s = \sqrt{K_{sp}} = 0.71 \times 10^{-6}$ |
| AgI | $8.3 \times 10^{-17} = s^2$ | $s = \sqrt{K_{sp}} = 0.9 \times 10^{-8}$ |

Solubility of $Ag_2CrO_4$ is highest thus, it will be precipitated at last.

**13. (a)**

**14. (a) :** The value of $K$ is high which means reaction proceeds almost to completion *i.e.,* the system will contain mostly products.

**15. (c) :** $Na_2CO_3$ which is a salt of NaOH (strong base) and $H_2CO_3$ (weak acid) will produce a basic solution with pH greater than 7.

**16. (b) :** $\Delta G° = -2.303RT\log K_{sp}$

$63.3 \times 10^3\ \text{J} = -2.303 \times 8.314 \times 298 \log K_{sp}$

$63.3 \times 10^3\ \text{J} = -5705.84 \log K_{sp}$

$$\log K_{sp} = -\frac{63.3\times10^3}{5705.84} = -11.09$$

$K_{sp} = \text{antilog}\,(-11.09) = 8.128 \times 10^{-12}$

**17. (d) :** As the forward reaction is exothermic and leads to lowering of pressure (produces lesser number of gaseous moles) hence, according to Le Chatelier's principle, at high pressure and low temperature, the given reversible reaction will shift in forward direction to form more product.

**18. (a) :** $\log\dfrac{K'_p}{K_p} = -\dfrac{\Delta H}{2.303R}\left[\dfrac{1}{T_2} - \dfrac{1}{T_1}\right]$

For exothermic reaction, $\Delta H = -\text{ve}$ *i.e.* heat is evolved. The temperature $T_2$ is higher than $T_1$.

Thus, $\left(\dfrac{1}{T_2} - \dfrac{1}{T_1}\right)$ is negative.

so, $\log K'_p - \log K_p = -\text{ve}$ or $\log K_p > \log K'_p$

or $K_p > K'_p$

**19. (a) :** HCl and $SO_2$ are reducing agents. So they can reduce $MnO_4^-$.

$CO_2$ is neither oxidising nor reducing agent, it will provide only acidic medium. It can shift the reaction in forward direction and the reaction can go to completion.

**20. (a) :** $BF_3$ is Lewis acid ($e^-$ pair acceptor).

**21. (b) :** Degree of dissociation, $\alpha = \dfrac{3.7}{100} = 0.037$

According to Ostwald's formula,

$K_a = \alpha^2 C = (0.037)^2 \times 0.10 = 1.369 \times 10^{-4} \approx 1.4 \times 10^{-4}$

**22. (d) :** We know that, at 25°C, $K_w = 1 \times 10^{-14}$

At 100°C, $K_w = 55 \times 10^{-14}$

$H^+ = \sqrt{55\times10^{-14}}$

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

$$\text{pH} = -\log\left[\sqrt{55\times10^{-14}}\right]$$

$$= \frac{1}{2}[-\log(55\times10^{-14})] = \frac{1}{2}[-\log 55 + 14\log 10]$$

$$= \frac{1}{2}[-1.74 + 14] = \frac{1}{2}[12.26] = 6.13$$

**23. (d) :** $CaCO_3 \rightarrow \underset{x}{Ca^{2+}} + \underset{x}{CO_3^{2-}}$

$CaC_2O_4 \rightarrow \underset{y}{Ca^{2+}} + \underset{y}{C_2O_4^{\ 2-}}$

Now, $[Ca^{2+}] = x + y$

and $x(x + y) = 4.7 \times 10^{-9}$ ...(i)

$y(x + y) = 1.3 \times 10^{-9}$ ...(ii)

Dividing equation (i) and (ii) we get

$$\frac{x}{y} = 3.6$$

$\therefore\ x = 3.6y$

Putting this value in equation (ii), we get

$y(3.6y + y) = 1.3 \times 10^{-9}$

On solving, we get $y = 1.68 \times 10^{-5}$

and $x = 3.6 \times 1.68 \times 10^{-5} = 6.048 \times 10^{-5}$

$\therefore\ [Ca^{2+}] = (x + y) = (1.68 \times 10^{-5}) + (6.048 \times 10^{-5})$

$\therefore\ [Ca^{2+}] = 7.728 \times 10^{-5}\ \text{M}$

**24. (b) :** $\text{pH} = \text{p}K_a + \log\dfrac{[\text{Salt}]}{[\text{Acid}]}$

$5 = -\log K_a + \log\dfrac{[\text{Salt}]}{[\text{Acid}]}$ $[\because \text{p}K_a = -\log K_a]$

$5 = -\log\,[1 \times 10^{-4}] + \log\dfrac{[\text{Salt}]}{[\text{Acid}]}$

$5 = 4 + \log\dfrac{[\text{Salt}]}{[\text{Acid}]}$

$5 - 4 = \log\dfrac{[\text{Salt}]}{[\text{Acid}]}$

$1 = \log\dfrac{[\text{Salt}]}{[\text{Acid}]}$

$\dfrac{[\text{Salt}]}{[\text{Acid}]} = 10 = 10 : 1$

**25. (b) :** pH of solution = 12

$[H^+] = 10^{-12}$

$$[OH^-] = \frac{10^{-14}}{10^{-12}} = 10^{-2}$$

$Ba(OH)_2 \rightleftharpoons \underset{s}{Ba^{2+}} + \underset{2s}{2OH^-}$

$2s = 10^{-2} \Rightarrow s = \dfrac{10^{-2}}{2}$

$K_{sp} = (s)\,(2s)^2 = 4s^3$

$$= 4\times\left(\frac{10^{-2}}{2}\right)^3 = \frac{4}{8}\times10^{-6} = 5\times10^{-7}$$

**26.** **(a) :** $BaCl_2$ is made up of $Ba(OH)_2$ and HCl.
$AlCl_3$ is made up of $Al(OH)_3$ and HCl.
LiCl is made up of LiOH and HCl.
$BeCl_2$ is made up of $Be(OH)_2$ and HCl.
$Ba(OH)_2$ is strongest base among the given options thus have maximum pH.

**27.** **(a)**

**28.** **(c) :** $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$ ...(i)
$K = 278$

By reversing the equation (i), we get

$2SO_{3(g)} \rightleftharpoons 2SO_{2(g)} + O_{2(g)}$ ...(ii)

Equilibrium constant for this reaction is

$$K' = \frac{1}{K} = \frac{1}{278}$$

By dividing the equation (ii) by 2, we get desired equation,

$SO_{3(g)} \rightleftharpoons SO_{2(g)} + \frac{1}{2}O_{2(g)}$ ...(iii)

Equilibrium constant for this reaction

$$K'' = \sqrt{K'} = \sqrt{\frac{1}{K}} = \sqrt{\frac{1}{278}} = 0.0599 \approx 0.06 \text{ or } 6\times10^{-2}$$

**29.** **(c) :** $A_{2(g)} + B_{2(g)} \rightleftharpoons 2AB_{(g)}$

$$K_c = \frac{[AB]^2}{[A_2][B_2]}$$

$$= \frac{(2.8\times10^{-3})^2}{(3.0\times10^{-3})(4.2\times10^{-3})} = \frac{2.8\times2.8}{4.2\times3.0} = 0.62$$

**30.** **(d) :** $X_{2(g)} + 4Y_{2(g)} \rightleftharpoons 2XY_{4(g)}$

$\Delta n_g = -\text{ve}$ and $\Delta H = -\text{ve}$

The reaction is favoured in forward direction at low temperature and high pressure.

**31.** **(b) :** $[NH_3] = 0.30$ M, $K_b = 1.8\times10^{-5}$
$[NH_4^+] = 0.20$ M

$$\text{pOH} = \text{p}K_b + \log\frac{[\text{salt}]}{[\text{base}]} = 4.74 + \log\frac{0.2}{0.3} = 4.56$$

$\text{pH} = (14 - 4.56) = 9.43$

**32.** **(c) :** $BF_3$ is an electron deficient species and acts as Lewis base.

**33.** **(c) :** $N_2 + O_2 \rightleftharpoons 2NO\ ;\ K_1$
$2NO + O_2 \rightleftharpoons 2NO_2\ ;\ K_2$
$NO_2 \rightleftharpoons \frac{1}{2}N_2 + O_2 ;\ K$

$$K_1 = \frac{[NO]^2}{[N_2][O_2]}\ ;\ K_2 = \frac{[NO_2]^2}{[NO]^2[O_2]}$$

$$K = \frac{[N_2]^{1/2}[O_2]}{[NO_2]} = \sqrt{\frac{[N_2][O_2]\times[NO]^2[O_2]}{[NO]^2\times[NO_2]^2}}$$

$$K = \sqrt{\frac{1}{K_1K_2}}$$

**34.** **(c) :** $K_{sp}[AgCl] = [Ag^+][Cl^-]$

$$[Ag^+] = \frac{1.8\times10^{-10}}{10^{-1}} = 1.8\times10^{-9}\ \text{M}$$

$K_{sp}[PbCl_2] = [Pb^{2+}][Cl^-]^2$

$$[Pb^{2+}] = \frac{1.7\times10^{-5}}{10^{-1}\times10^{-1}} = 1.7\times10^{-3}\ \text{M}$$

**35.** **(d) :** We Know, $\text{pH} + \text{pOH} = 14$
Here, $12 + \text{pOH} = 14$
$\text{pOH} = 2$
$[OH^-] = 10^{-2}$

$$\begin{array}{ccc} Ba(OH)_2 \rightleftharpoons & Ba^{2+} & + 2OH^- \\ & s & 2s \end{array}$$

$2S = [OH^-] = 10^{-2}$

$$s = \frac{10^{-2}}{2} = 5\times10^{-3}\ \text{M}$$

$K_{sp} = [Ba^{2+}][OH^-]^2 = (5\times10^{-3})(10^{-2})^2$
$K_{sp} = 5\times10^{-7}$

**36.** **(d) :**
$$\begin{array}{ccccc} CH_3COOH & \rightleftharpoons & CH_3COO^- & + & H^+ \\ C - x & & x & & x \end{array}$$

$$\begin{array}{ccccc} CH_3COONa & \rightarrow & CH_3COO^- & + & Na^+ \\ 0.2\ \text{M} & & 0.2\ \text{M} & & 0.2\ \text{M} \end{array}$$

$$\left.\begin{array}{l} [CH_3COOH] = C - x \approx 0.1\ \text{M} \\ [CH_3COO^-] = 0.2 + x \approx 0.2\ \text{M} \end{array}\right\} \begin{array}{l}\text{acetic acid is a} \\ \text{weak acid so,} \\ \text{dissociation is} \\ \text{minimum.}\end{array}$$

$$\therefore\ [H^+] = \frac{K_a[CH_3COOH]}{[CH_3COO^-]}$$

$$= \frac{1.8\times10^{-5}\times10^{-1}}{2\times10^{-1}} = 9\times10^{-6}\ \text{M}$$

**37.** **(d) :** $K_p$ and $K_c$ are related by the equation,

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

where $\Delta n_g$ = difference in the no. of moles of products and reactants in the gaseous state.

for $2C_{(s)} + O_{2(g)} \rightleftharpoons 2CO_{2(g)}$
$\Delta n_g = 2 - (1) = 1 \neq 0$

**38.** **(d) :** We know, $\text{pOH} = \text{p}K_b + \log\frac{[B^-]}{[HB]}$

Since, $[B^-] = [HB]$ (given)

$\therefore\ \text{pOH} = \text{p}K_b \Rightarrow \text{pOH} = 10$

$\therefore\ \text{pH} = 14 - 10 = 4$

**39. (b) :** $2A_{(g)} + B_{(g)} \rightleftharpoons 3C_{(g)} + D_{(g)}$

| | $2A_{(g)}$ | $B_{(g)}$ | $3C_{(g)}$ | $D_{(g)}$ |
|---|---|---|---|---|
| Initial moles : | 1 | 1 | 0 | 0 |
| Moles at eq. : | $1-(2\times0.25)$<br>$=0.5$ | $1-0.25$<br>$=0.75$ | $3\times0.25$<br>$=0.75$ | $0.25$<br>$=0.25$ |

Equilibrium constant, $K=\dfrac{[C]^3[D]}{[A]^2[B]}$

$$\therefore\quad K=\frac{(0.75)^3(0.25)}{(0.5)^2(0.75)}$$

**40. (c) :** Given,

$$\mathrm{CH_3COOH \rightleftharpoons CH_3COO^- + H^+}$$

$$K_1=\frac{[\mathrm{CH_3COO^-}][\mathrm{H^+}]}{[\mathrm{CH_3COOH}]}=1.5\times10^{-5}$$

$$\mathrm{HCN \rightleftharpoons H^+ + CN^-}$$

$$K_2=\frac{[\mathrm{CN^-}][\mathrm{H^+}]}{[\mathrm{HCN}]}=4.5\times10^{-10}$$

$$\mathrm{CN^- + CH_3COOH \rightleftharpoons HCN + CH_3COO^-}$$

$$K=\frac{[\mathrm{HCN}][\mathrm{CH_3COO^-}]}{[\mathrm{CN^-}][\mathrm{CH_3COOH}]}$$

$$K=\frac{K_1}{K_2}=\frac{1.5\times10^{-5}}{4.5\times10^{-10}}\approx0.3\times10^{5}$$

or $K = 3 \times 10^4$

**41. (d) :** Lewis acids are electron deficient compounds, since $(\mathrm{CH_3})_3\mathrm{B}$ is electron deficient (due to incomplete octect of B), it acts as a Lewis acid.

**42. (d) :** $\mathrm{NH_4Cl}$ is a salt of strong acid and weak base, so hydrolysis constant is

$$K_h=\frac{K_w}{K_b}$$

Given, $K_b\,(\mathrm{NH_4OH}) = 1.77 \times 10^{-5}$

$K_w = 10^{-14}$

$$\therefore\quad K_h=\frac{10^{-14}}{1.77\times10^{-5}}=0.565\times10^{-9}$$

or $K_h = 5.65 \times 10^{-10}$

**43. (d) :** Millimoles of $\mathrm{H^+}$ produced = 20 × 0.05 = 1

Millimoles of $\mathrm{OH^-}$ produced = 30 × 0.1 × 2 = 6

($\because$ Each $\mathrm{Ba(OH)_2}$ gives $2\mathrm{OH^-}$.)

$\therefore$ Millimoles of $\mathrm{OH^-}$ remaining in solution

$= 6 - 1 = 5$

Total volume of solution = 20 + 30 = 50 mL

$$\therefore\quad [\mathrm{OH^-}]=\frac{5}{50}=0.1\ \mathrm{M}$$

**44. (d) :** $2AB_{2(g)} \rightleftharpoons 2AB_{(g)} + B_{2(g)}$

| $2AB_{2(g)}$ | $2AB_{(g)}$ | $B_{2(g)}$ | |
|---|---|---|---|
| 2 | 0 | 0 | (initially) |
| $2(1-x)$ | $2x$ | $x$ | (at equilibrium) |

Amount of moles at equilibrium $= 2(1-x) + 2x + x$
$= 2 + x$

$$K_p=\frac{[p_{AB}]^2\,[p_{B_2}]}{[p_{AB_2}]^2}$$

$$K_p=\frac{\left(\dfrac{2x}{2+x}\times P\right)^2\times\left(\dfrac{x}{2+x}\times P\right)}{\left(\dfrac{2(1-x)}{2+x}\times P\right)^2}=\frac{\dfrac{4x^3}{2+x}\times P}{4(1-x)^2}$$

$$K_p=\frac{4x^3\times P}{2}\times\frac{1}{4}\qquad(\because\ \ 1-x\approx1\ \&\ 2+x\approx2)$$

$$x=\left(\frac{8K_p}{4P}\right)^{1/3}\quad\Rightarrow\quad x=\left(\frac{2K_p}{P}\right)^{1/3}$$

**45. (a) :** $\mathrm{Fe(OH)_{3(s)} \rightleftharpoons Fe^{3+}_{(aq)} + 3OH^-_{(aq)}}$

$$K=\frac{[\mathrm{Fe^{3+}}]\,[\mathrm{OH^-}]^3}{[\mathrm{Fe(OH)_3}]}$$

$K = [\mathrm{Fe^{3+}}]\,[\mathrm{OH^-}]^3$ (activity of solid is taken unity)

Concentration of $\mathrm{OH^-}$ ion in the reaction is decreased by 1/4 times then equilibrium concentration of $\mathrm{Fe^{3+}}$ will be increased by 64 times in order to keep the value of $K$ constant.

**46. (d) :** $\mathrm{pH} = -\log[\mathrm{H^+}]$

or $[\mathrm{H^+}] = 10^{-\mathrm{pH}}$; $[\mathrm{H^+}]$ of soln. 1 = $10^{-3}$

$[\mathrm{H^+}]$ of soln. 2 = $10^{-4}$; $[\mathrm{H^+}]$ of soln. 3 = $10^{-5}$

Total concentration of $[\mathrm{H^+}]$

$= 10^{-3}(1 + 1 \times 10^{-1} + 1 \times 10^{-2})$

$$\Rightarrow\ 10^{-3}\left(\frac{1}{1}+\frac{1}{10}+\frac{1}{100}\right)\ \Rightarrow\ 10^{-3}\left(\frac{100+10+1}{100}\right)$$

$$\Rightarrow\ 10^{-3}\left(\frac{111}{100}\right)=1.11\times10^{-3}$$

So, $\mathrm{H^+}$ ion concentration in mixture of equal volume of these acid solution $=\dfrac{1.11\times10^{-3}}{3}$ = 3.7 × $10^{-4}$ M

**47. (d) :** $\mathrm{HI_{(g)} \rightleftharpoons 1/2H_{2(g)} + 1/2I_{2(g)}}$

*i.e.* $K=\dfrac{[\mathrm{H_2}]^{1/2}[\mathrm{I_2}]^{1/2}}{[\mathrm{HI}]}=8$

$$\mathrm{H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}}$$

$$K'=\frac{[\mathrm{HI}]^2}{[\mathrm{H_2}][\mathrm{I_2}]}=\left(\frac{1}{8}\right)^2\ \Rightarrow\ K'=\frac{1}{64}$$

**48. (a) :** $X \rightleftharpoons Y + Z$ ...(i)

$A \rightleftharpoons 2B$ ...(ii)

| $X$ | $\rightleftharpoons\ Y$ | $+\ Z$ | |
|---|---|---|---|
| 1 | 0 | 0 | Initially |
| $1-\alpha$ | $\alpha$ | $\alpha$ | At equilibrium |

Total no. of moles at equilibrium = $1 - \alpha + 2\alpha = 1 + \alpha$

Similarly,

$A \rightleftharpoons 2B$

1 0 Initially

$1-\alpha$ $2\alpha$ At equilibrium

Total no. of moles at equilibrium = $1 - \alpha + 2\alpha = 1 + \alpha$

$$\therefore\ K_{p_1} = \frac{p_Y \times p_Z}{p_X} = \frac{\frac{\alpha}{1+\alpha} \times P_1 \times \frac{\alpha}{1+\alpha} \times P_1}{\frac{1-\alpha}{1+\alpha} \times P_1}$$

$$K_{p_2} = \frac{(p_B)^2}{p_A} = \frac{\left(\frac{2\alpha}{1+\alpha} \times P_2\right)^2}{\frac{1-\alpha}{1+\alpha} \times P_2}$$

Now $\frac{K_{p_1}}{K_{p_2}} = \frac{P_1}{4P_2} \Rightarrow \frac{P_1}{P_2} = \frac{36}{1} = 36:1$

**49. (a) :** For a weak acid, degree of dissociation,

$$\alpha = \sqrt{\frac{K_a}{C}} = \sqrt{\frac{1 \times 10^{-5}}{0.1}} = 10^{-2} \quad \textit{i.e.}\ 1.00\%$$

**50. (a) :** Given, $[H_3O^+] = 1 \times 10^{-10}$ or, pH = 10

Now at 25°C, pH + pOH = $pK_w = 14$

or, pOH = 14 – pH = 14 – 10 = 4

**51. (c) :** $CH_{4(g)} + 2O_{2(g)} \rightleftharpoons CO_{2(g)} + 2H_2O_{(l)}$

$$K_p = \frac{P_{CO_2}}{P_{CH_4} \cdot P_{O_2}^2}$$

**52. (b) :** $HNO_2$ and $NaNO_2$ are examples of acidic buffer.

**53. (c) :** $10^{-8}$ M HCl = $10^{-8}$ M $H^+$

Also from water, $[H^+] = 10^{-7}$

Total $[H^+] = 10^{-7} + 0.10 \times 10^{-7} = 1.1 \times 10^{-7}$

**54. (d) :** $C = 0.01$ M

$K_b = 1 \times 10^{-12}$ at 25°C

$BOH \rightleftharpoons B^+ + OH^-$

$C$ 0 0

at eq. $C - C\alpha$ $C\alpha$ $C\alpha$

$[OH^-] = C\alpha$

$[OH^-] = \sqrt{K_b C} = \sqrt{1 \times 10^{-12} \times 10^{-2}}$

$[OH^-] = 10^{-7}$ mol $L^{-1}$

**55. (a) :** The cation of group II are precipitated as their sulphides.

Solubility product of sulphide of group II radicals are very low. Therefore, even with low conc. of $S^{2-}$ ions, the ionic product exceeds the value of their solubility product and the radical of group II gets precipitated. The low conc. of $S^{2-}$ ions is obtained by passing $H_2S$ gas through the solution of the salt in the presence of dil. HCl which suppresses degree of ionisation of $H_2S$ by common ion effect.

$$H_2S \rightleftharpoons \boxed{\begin{array}{c}2H^+\\ H^+\end{array}}\ \begin{array}{l}+\,S^{2-}\\ +\,Cl^-\end{array}$$

common ion

**Note:** Solubility product of group IV radicals are quite high.

It is necessary to suppress the conc. of $S^{2-}$ ions, otherwise radical of group IV will also get precipitated along with group II radicals.

**56. (a) :** $K_1 = \frac{P_{NO_2}}{P_{NO} \cdot (P_{O_2})^{1/2}}$ ...(1)

$K_2 = \frac{(P_{NO})^2 \cdot Po_2}{(P_{NO_2})^2}$ ...(2)

taking square root on both sides in eq. 2.

$$\Rightarrow \sqrt{K_2} = \frac{P_{NO} \cdot (Po_2)^{1/2}}{P_{NO_2}}$$

$$\Rightarrow \sqrt{K_2} = \frac{1}{K_1}\ ;\ \Rightarrow K_2 = \frac{1}{K_1^2}$$

**57. (c) :** $K_{sp} = 3.2 \times 10^{-11}$

$AX_2 \rightleftharpoons A^{2+} + 2X^-$

$s$ $2s$

$K_{sp} = s \times (2s)^2 = 4s^3$; *i.e.*, $3.2 \times 10^{-11} = 4s^3$

or, $s^3 = 0.8 \times 10^{-11} = 8 \times 10^{-12}$

$\therefore$ $s = 2 \times 10^{-4}$

**58. (d) :** Let us consider the formation of a salt of a weak acid and a strong base.

$In^- + H_2O \rightleftharpoons HIn + OH^-$

$K_h = \frac{[HIn][OH^-]}{[In^-]}$ ...(i)

Other equations present in the solution are

$HIn \rightleftharpoons H^+ + In^-$

$H_2O \rightleftharpoons H^+ + OH^-$

$K_{In} = \frac{[H^+][In^-]}{[HIn]}$ ... (ii)

$K_w = [H^+]\,[OH^-]$ ... (iii)

From (ii) and (iii),

$\frac{K_w}{K_{In}} = \frac{[HIn][OH^-]}{[In^-]} = K_h$ ... (iv)

$$[OH^-] = \frac{K_w}{K_{In}} \frac{[In^-]}{[HIn]}$$

$$\log[OH^-] = \log K_w - \log K_{In} + \log\frac{[In^-]}{[HIn]}$$

$$-pOH = -pK_w + pK_{In} + \log\frac{[In^-]}{[HIn]}$$

$$pK_w - pOH = pK_{In} + \log\frac{[In^-]}{[HIn]}$$

or, $pH = pK_{In} + \log\frac{[In^-]}{[HIn]}$

*i.e.* $\log\frac{[In^-]}{[HIn]} = pH - pK_{In}$

**59. (b) :** $3H_2 + N_2 \rightarrow 2NH_3$

$$\begin{array}{ccc} 3 & 1 & 2 \\ 3/2 & 1/2 & 1 \\ 10\times\frac{3}{2} & 10\times\frac{1}{2} & 10\times 1 \\ 15 & 5 & 10 \end{array}$$

Composition of gaseous mixture under the aforesaid condition in the end

$H_2 = 30 - 15 = 15$ litres

$N_2 = 30 - 5 = 25$ litres

$NH_3 = 10$ litres

**60. (c) :** $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}\ ;\quad \Delta n = 2 - 4 = -2$$

Thus the reaction will shift in forward direction when $Q > K_c$.

**61. (d) :** Due to strong hydrogen-fluorine bond, proton is not given off easily and hence, HF is weakest acid.

**62. (b) :** $AgI \rightleftharpoons Ag^+ + I^-$

$1.0 \times 10^{-16} = s \times s$

Solubility of $Ag^+ = 1.0 \times 10^{-8}$ mol $L^{-1}$

Solubility of AgI in KI solution $= 1.0 \times 10^{-8} \times 10^{-4}$

$= 1.0 \times 10^{-12}$ mol $L^{-1}$

**63. (c) :** Pressure of $O_2$ does not depend on concentration terms of other reactants (because both are in solid state), since this is an endothermic reaction. If the temperature be raised dissociation of $BaO_2$ would occur, more $O_2$ is produced at equilibrium, pressure of $O_2$ increases.

**64. (d) :** If $s$ is the solubility of the electrolyte $MX_2$

$C_{M^{2+}} = s,\ C_{X^-} = 2s$

Solubility product, $K_{sp} = s \times (2s)^2 = 4s^3$;

$s = 0.5 \times 10^{-4}$ mole/litre

$\therefore\ K_{sp} = 4 \times (0.5 \times 10^{-4})^3\ ;\ K_{sp} = 5 \times 10^{-13}$

**65. (b) :** $NH_4OH$ is a weak base but HCl is a strong acid in solution, so pH of $NH_4Cl$ solution is comparatively low.

$NaNO_3$ is a salt of strong base and strong acid, so pH of the solution will be 7.

Hydrolysis of potassium acetate (a salt of a weak acid and a strong alkali) gives a weakly alkaline solution, since the acetate ion acts as a weak base.

$$CH_3COOK + H_2O \rightarrow CH_3COOH + K^+ + OH^-$$

The pH of this solution ≈ 8.8.

Hydrolysis of sodium carbonate (a salt of strong alkali and a weak acid) gives an alkaline solution

$$Na_2CO_3 + 2H_2O \rightarrow 2(Na^+ + OH^-) + H_2CO_3$$

The pH of this solution is > 10.

**66. (b) :** Solution of 0.1 N $NH_4OH$ and 0.1 N $NH_4Cl$ is a buffer solution.

According to Henderson equation, the pH of a basic buffer,

$$pH = 14 - pK_b - \log\frac{C_{\text{salt}}}{C_{\text{base}}}$$

$$\Rightarrow\ pK_b = 14 - pH - \log\frac{C_{\text{salt}}}{C_{\text{base}}}$$

$$\Rightarrow\ pK_b = 14 - 9.25 - \log\frac{0.1}{0.1}$$

$$\Rightarrow\ pK_b = 14 - 9.25 = 4.75$$

$\therefore\ pK_b$ of $NH_4OH = 4.75$

**67. (c) :** Proton accepting tendency is known as the strength of basicity.

In $R\text{—}\ddot{N}H_2$, N has lone pair of electron which intensify due to electron releasing $R$-group and increase the tendency to donate lone pair of electrons to $H^+$.

Secondly as the size of the ion increases there is less attraction for $H^+$ to form weaker bonds with H – atom and are less basic. The order of the given series: $RNH_2 > NH_3 > HS^- > I^-$.

**68. (d) :** $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$

$$K_{\text{ion}} = \frac{[CH_3COO^-][H^+]}{[CH_3COOH]}$$

$$[CH_3COOH] = \frac{3.4\times10^{-4}\times3.4\times10^{-4}}{1.7\times10^{-5}} = 6.8 \times 10^{-3}$$

**69. (b) :** For reaction,

$$M_2S \rightleftharpoons 2M^+ + S^{2-}$$

Solubility $= 3.5 \times 10^{-6}$

Solubility product, $K_{sp} = [M^+]^2\,[S^{2-}]$

$= (2s)^2\, s = 4s^3 = 4 \times (3.5 \times 10^{-6})^3 = 1.7 \times 10^{-16}$

**70. (b) :** (i) $H_2A \overset{K_{a_1}}{\rightleftharpoons} HA^- + H^+$

(ii) $HA^- \overset{K_{a_2}}{\rightleftharpoons} A^{2-} + H^+$

In the 1st step $H^+$ ion comes from neutral molecule, while in the 2nd step the $H^+$ ion comes from negatively charged ions. The presence of –ve charge makes the removal $H^+$ ion difficult. Thus, $K_{a_1} > K_{a_2}$.

**71. (b) :** For a reaction, $A + B \rightleftharpoons C + D$.

$$K_{eq} = \frac{[C]\,[D]}{[A]\,[B]}$$

Increase in conc. of reactants will proceed the equilibrium in the forward direction giving more products. So that the equilibrium constant value remains constant and independent of concentration.

**72. (d) :** $NH_2^- + H^+ \rightarrow NH_3$ (conjugate acid)
Substance + $H^+$ → conjugate acid
Substance – $H^+$ → conjugate base.

**73. (b) :** After mixing 1 N solution of $CH_3COOH$ (weak acid) and 1 N NaOH (strong base), the resulting solution will have free $OH^-$ ions. Thus pH will be higher than 7.

**74. (a) :** $K_p = P_{CO_2}$

Solids do not exert pressure, so their partial pressure is taken as unity.

**75. (d) :** $\underset{\text{Weak acid}}{CH_3COOH} \rightleftharpoons \underset{\text{Conjugate base}}{CH_3COO^-} + H^+$

As $CH_3COOH$ is the weakest acid, so its conjugate base ($CH_3COO^-$) is the strongest base. $H_2SO_4$, HCl, $HNO_3$ are strong acids, so their conjugate bases are weak.

**76. (a) :** $[H^+] = C\alpha = 0.1 \times 0.02 = 2 \times 10^{-3}$ M
(As degree of dissociation = 2% = 0.02)

Hence $[OH^-] = \dfrac{10^{-14}}{2\times10^{-3}} = 5 \times 10^{-12}$ M

**77. (d) :** For $CaF_2$, decomposition is as follows:

$$\underset{s}{CaF_2} \rightarrow \underset{s}{Ca^{2+}} + \underset{2s}{2F^-}$$

$\Rightarrow K_{sp} = [Ca^{2+}]\,[F^-]^2 = s \times (2s)^2$
or, $K_{sp} = 4s^3 \Rightarrow K_{sp} = 4s^3 = 4 \times (2 \times 10^{-4})^3$
$\Rightarrow K_{sp} = 32 \times 10^{-12}$

**78. (d) :** Given,

$XeF_6 + H_2O \rightleftharpoons XeOF_4 + 2HF, K_{eq} = K_1$
$XeOF_4 + 2HF \rightleftharpoons XeF_6 + H_2O, K_{eq} = 1/K_1$ ...(1)
and $XeO_4 + XeF_6 \rightleftharpoons XeOF_4 + XeO_3F_2, K_{eq} = K_2$ ...(2)

The reaction, $XeO_4 + 2HF \rightleftharpoons XeO_3F_2 + H_2O$, can be obtained by adding eq. (1) and eq.(2).
So, the equilibrium constant for the above reaction can be obtained by multiplying the equilibrium constants of eq. (1) and eq. (2).

Hence, the value is = $\dfrac{K_2}{K_1}$

**79. (b) :** $pH = pK_a + \log\dfrac{[\text{Salt}]}{[\text{Acid}]}$

For small concentration of buffering agent and for maximum buffer capacity [Salt]/[Acid] ≈ 1
*i.e.*, pH = $pK_a$.

**80. (d) :** $NaH + H_2O \rightarrow NaOH + H_2$
or, $H^-_{(aq)} + H_2O_{(l)} \rightarrow OH^- + H_2\uparrow$
Hydride ions will abstract proton from NaOH and hydrogen gas will evolve as a result of it.

**81. (b) :** The greater the solubility product, the greater is the solubility.

**82. (c) :** The equilibrium constant for the reverse reaction will be $1/K$.

**83. (d) :** At high temperature, the value of ionic product increases.

**84. (c) :** Total number of moles = $2(1 - \alpha) + 2\alpha = 2$

**85. (b) :** Since NaOH is a strong base, therefore it completely ionises. Thus, the hydroxyl ion concentration is equal to that of the base itself. We know that concentration of $OH^-$ in $N/10$ NaOH = $0.1 = 10^{-1}$. Therefore value of

$$H_3O^+ = \frac{K_w}{[OH^-]} = \frac{1\times10^{-14}}{10^{-1}} = 1 \times 10^{-13}$$

$$pH = -\log[H_3O^+] = -\log[1 \times 10^{-13}] = 13$$

**86. (b) :** In $BF_3$ and $FeCl_3$ molecules, the central atoms have incomplete octet and in $SiF_4$, the central atom has empty *d*-orbitals. Hence, according to Lewis concept, these are Lewis acids.

**87. (d) :** The pH value of the blood is maintained constant by buffer solution present in the blood itself. Buffer solutions resist the change in pH values.

**88. (c) :** Since HCl is a strong acid and it completely ionises, therefore $H_3O^+$ ions concentration is equal that of the acid itself *i.e.* $[H_3O^+] = [HCl] = 10$ M.

Therefore $pH = -\log[H_3O^+] = -\log[10] = -1$

**89. (a) :** There are greater number of particles (*i.e.* ions) compared to others. Hence, solubility will be minimum.

**90. (a) :** Vapour pressure is directly related to temperature. Greater is the temperature, greater will be the vapour pressure. So to keep it constant, temperature should be constant.

**91. (d) :** Higher the value of solubility product, greater is the solubility.

**92. (a) :** $[H_3O^+] = [OH^-] = 1 \times 10^{-6}$ mole/litre
$K_w = [H_3O^+][OH^-] = [1 \times 10^{-6}] \times [1 \times 10^{-6}] = 1 \times 10^{-12}$

**93. (d) :** When solid and liquid are in equilibrium, the increase in temperature results in increase in volume of liquid or decrease in the amount of solid.

$$\text{Solid} \rightleftharpoons \text{Liquid}$$

With increase in temperature equilibrium shifts in forward direction.

**94. (a) :** Sodium borate is a salt formed from strong base (NaOH) and weak acid ($H_3BO_3$). Hence, sodium borate will act basic.

**95. (d) :** According to Le Chatelier's principle, if an equilibrium is subjected to a change in concentration, pressure or temperature, etc. equilibrium shift in such a way so as to undo the effect of a change imposed.

**96. (b) :** $CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$

**97. (a) :** Reaction (ii) is the reversible reaction of (i) and is half of the reaction (i). Thus, rate constant can be given as:

$$K_2 = \sqrt{\frac{1}{K_1}} \text{ or } K_1 = \left[\frac{1}{K_2}\right]^2$$

**98. (c) :** $NH_4Cl$ and $NaHCO_3$ are acidic in nature and NaCl is neutral. Only $Na_2CO_3$ is basic and thus have highest pH.