CHAPTER 7

Equilibrium

1. An aqueous solution contains 0.10 M H_2S and 0.20 M HCl. If the equilibrium constants for the formation of HS^- from H_2S is 1.0×10^{-7} and that S^{2-} from HS^- ions is 1.2×10^{-13} then the concentration of S^{2-} ions in aqueous solution is
(a) 5×10^{-8} (b) 3×10^{-20}
(c) 6×10^{-21} (d) 5×10^{-19} *(2018)*

2. An aqueous solution contains an unknown concentration of Ba^{2+}. When 50 mL of a 1 M solution of Na_2SO_4 is added, $BaSO_4$ just begins to precipitate. The final volume is 500 mL. The solubility product of $BaSO_4$ is 1×10^{-10}. What is the original concentration of Ba^{2+} ?
(a) 5×10^{-9} M (b) 2×10^{-9} M
(c) 1.1×10^{-9} M (d) 1.0×10^{-10} M *(2018)*

3. Which of the following are Lewis acids?
(a) PH_3 and BCl_3 (b) $AlCl_3$ and $SiCl_4$
(c) PH_3 and $SiCl_4$ (d) BCl_3 and $AlCl_3$
(2018)

4. Which of the following salts is the most basic in aqueous solution?
(a) $Al(CN)_3$ (b) CH_3COOK
(c) $FeCl_3$ (d) $Pb(CH_3COO)_2$ *(2018)*

5. In which of the following reactions, an increase in the volume of the container will favour the formation of products?
(a) $2NO_{2(g)} \rightleftharpoons 2NO_{(g)} + O_{2(g)}$ (b) $3O_{2(g)} \rightleftharpoons 2O_{3(g)}$
(c) $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$
(d) $4NH_{3(g)} + 5O_{2(g)} \rightleftharpoons 4NO_{(g)} + 6H_2O_{(l)}$ *(Online 2018)*

6. The minimum volume of water required to dissolve 0.1 g lead (II) chloride to get a saturated solution (K_{sp} of $PbCl_2$ = 3.2×10^{-8} ; atomic mass of Pb = 207 u) is
(a) 0.36 L (b) 0.18 L (c) 17.98 L (d) 1.798 L
(Online 2018)

7. Which of the following is a Lewis acid?
(a) NaH (b) NF_3 (c) PH_3 (d) $B(CH_3)_3$
(Online 2018)

8. Following four solutions are prepared by mixing different volumes of NaOH and HCl of different concentrations, pH of which one of them will be equal to 1?
(a) $75\text{ mL}\ \frac{M}{5}\ \text{HCl} + 25\text{ mL}\ \frac{M}{5}\ \text{NaOH}$
(b) $100\text{ mL}\ \frac{M}{10}\ \text{HCl} + 100\text{ mL}\ \frac{M}{10}\ \text{NaOH}$
(c) $55\text{ mL}\ \frac{M}{10}\ \text{HCl} + 45\text{ mL}\ \frac{M}{10}\ \text{NaOH}$
(d) $60\text{ mL}\ \frac{M}{10}\ \text{HCl} + 40\text{ mL}\ \frac{M}{10}\ \text{NaOH}$ *(Online 2018)*

9. At a certain temperature in a 5 L vessel, 2 moles of carbon monoxide and 3 moles of chlorine were allowed to reach equilibrium according to the reaction,

$$CO + Cl_2 \rightleftharpoons COCl_2$$

At equilibrium, if one mole of CO is present then equilibrium constant (K_c) for the reaction is
(a) 4 (b) 3 (c) 2 (d) 2.5
(Online 2018)

10. At 320 K, a gas A_2 is 20% dissociated to $A_{(g)}$. The standard free energy change at 320 K and 1 atm in J mol^{-1} is approximately
($R = 8.314$ JK^{-1} mol^{-1}; ln 2 = 0.693; ln 3 = 1.098)
(a) 4281 (b) 4763 (c) 2068 (d) 1844
(Online 2018)

11. The gas phase reaction, $2NO_{2(g)} \rightarrow N_2O_{4(g)}$ is an exothermic reaction. The decomposition of N_2O_4, in equilibrium mixture of $NO_{2(g)}$ and $N_2O_{4(g)}$, can be increased by
(a) addition of an inert gas at constant volume
(b) increasing the pressure
(c) lowering the temperature
(d) addition of an inert gas at constant pressure.
(Online 2018)

12. pK_a of a weak acid (HA) and pK_b of a weak base (BOH) are 3.2 and 3.4 respectively. The pH of their salt (AB) solution is
(a) 7.0 (b) 1.0 (c) 7.2 (d) 6.9
(2017)

13. Addition of sodium hydroxide solution to a weak acid (HA) results in a buffer of pH 6. If ionisation constant of HA is 10^{-5}, the ratio of salt to acid concentration in the buffer solution will be
(a) 5 : 4 (b) 1 : 10 (c) 4 : 5 (d) 10 : 1
(Online 2017)

14. 50 mL of 0.2 M ammonia solution is treated with 25 mL of 0.2 M HCl. If pK_b of ammonia solution is 4.75, the pH of the mixture will be
(a) 4.75 (b) 3.75 (c) 9.25 (d) 8.25
(Online 2017)

15. The equilibrium constant at 298 K for a reaction, $A + B \rightleftharpoons C + D$ is 100. If the initial concentration of all the four species were 1 M each, then equilibrium concentration of D (in mol L^{-1}) will be
(a) 0.182 (b) 0.818 (c) 1.818 (d) 1.182
(2016)

16. A solid XY kept in an evacuated sealed container undergoes decomposition to form a mixture of gases X and Y at temperature T. The equilibrium pressure is 10 bar in this vessel. K_p for this reaction is

(a) 25 (b) 100 (c) 10 (d) 5

(Online 2016)

17. The standard Gibbs energy change at 300 K for the reaction $2A \rightleftharpoons B + C$ is 2494.2 J. At a given time, the composition of the reaction mixture is $\mathrm{g}W = \frac{6}{7}\mathrm{lg}X\mathrm{i} = 7\ \mathrm{mzp}\ \mathrm{g}Y\mathrm{i} = \frac{6}{7}3$ The reaction proceeds in the [R = 8.314 J/K/mol, e = 2.718]

(a) forward direction because $Q < K_c$

(b) reverse direction because $Q < K_c$

(c) forward direction because $Q > K_c$

(d) reverse direction because $Q > K_c$. *(2015)*

18. Gaseous N_2O_4 dissociates into gaseous NO_2 according to the reaction, $N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$

At 300 K and 1 atm pressure, the degree of dissociation of N_2O_4 is 0.2. If one mole of N_2O_4 gas is contained in a vessel, then the density of the equilibrium mixture is

(a) 1.56 g/L (b) 3.11 g/L

(c) 4.56 g/L (d) 6.22 g/L *(Online 2015)*

19. For the equilibrium, $A_{(g)} \rightleftharpoons B_{(g)}$, ΔH is –40 kJ/mol. If the ratio of the activation energies of the forward (E_f) and reverse (E_b) reactions is then

(a) E_f = 60 kJ/mol; E_b = 100 kJ/mol

(b) E_f = 30 kJ/mol; E_b = 70 kJ/mol

(c) E_f = 80 kJ/mol; E_b = 120 kJ/mol

(d) E_f = 70 kJ/mol; E_b = 30 kJ/mol. *(Online 2015)*

20. The increase of pressure on ice $\rightleftharpoons$ water system at constant temperature will lead to

(a) no effect on that equilibrium

(b) a decrease in the entropy of the system

(c) a shift of the equilibrium in the forward direction

(d) an increase in the Gibbs energy of the system.

(Online 2015)

21. For the reaction, $SO_{2(g)} + \frac{1}{2}O_{2(g)} \rightleftharpoons SO_{3(g)}$,

if $K_p = K_c(RT)^x$ where the symbols have usual meaning then the value of x is (assuming ideality)

(a) 1 (b) – 1 (c) $-\frac{1}{2}$ (d) $\frac{1}{2}$ *(2014)*

22. How many litres of water must be added to 1 litre of an aqueous solution of HCl with a pH of 1 to create an aqueous solution with pH of 2?

(a) 9.0 L (b) 0.1 L (c) 0.9 L (d) 2.0 L

(2013)

23. The equilibrium constant (K_c) for the reaction $N_{2(g)} + O_{2(g)} \rightarrow 2NO_{(g)}$ at temperature T is 4×10^{-4}. The value of K_c for the reaction, $NO_{(g)} \rightarrow \frac{1}{2}N_{2(g)} + \frac{1}{2}O_{2(g)}$ at the same temperature is

(a) 2.5×10^2 (b) 4×10^{-4}

(c) 50.0 (d) 0.02 *(2012)*

24. The pH of a 0.1 molar solution of the acid HQ is 3. The value of the ionization constant, K_a of this acid is

(a) 1×10^{-3} (b) 1×10^{-5}

(c) 1×10^{-7} (d) 3×10^{-1} *(2012)*

25. A vessel at 1000 K contains CO_2 with a pressure of 0.5 atm. Some of the CO_2 is converted into CO on the addition of graphite. If the total pressure at equilibrium is 0.8 atm, the value of K is

(a) 1.8 atm (b) 3 atm

(c) 0.3 atm (d) 0.18 atm *(2011)*

26. At 25°C, the solubility product of $Mg(OH)_2$ is 1.0×10^{-11}. At which pH, will Mg^{2+} ions start precipitating in the form of $Mg(OH)_2$ from a solution of 0.001 M Mg^{2+} ions?

(a) 8 (b) 9 (c) 10 (d) 11

(2010)

27. Three reactions involving $H_2PO_4^-$ are given below:

(i) $H_3PO_4 + H_2O \longrightarrow H_3O^+ + H_2PO_4^-$

(ii) $H_2PO_4^- + H_2O \longrightarrow HPO_4^{2-} + H_3O^+$

(iii) $H_2PO_4^- + OH^- \longrightarrow H_3PO_4 + O^{2-}$

In which of the above does $H_2PO_4^-$ act as an acid?

(a) (i) only (b) (ii) only

(c) (i) and (ii) (d) (iii) only *(2010)*

28. Solubility product of silver bromide is 5.0×10^{-13}. The quantity of potassium bromide (molar mass taken as 120 g mol^{-1}) to be added to 1 litre of 0.05M solution of silver nitrate to start the precipitation of AgBr is

(a) 5.0×10^{-8} g (b) 1.2×10^{-10} g

(c) 1.2×10^{-9} g (d) 6.2×10^{-5} g *(2010)*

29. In aqueous solution the ionisation constants for carbonic acid are

$K_1 = 4.2 \times 10^{-7}$ and $K_2 = 4.8 \times 10^{-11}$

Select the correct statement for a saturated 0.034M solution of the carbonic acid.

(a) The concentration of H^+ is double that of CO_3^{2-}.

(b) The concentration of CO_3^{2-} is 0.034 M.

(c) The concentration of CO_3^{2-} is greater than that of HCO_3^-.

(d) The concentration of H^+ and HCO_3^- are approximately equal. *(2010)*

30. The correct order of increasing basicity of the given conjugate bases (R = CH_3) is

(a) $RCOO^- < HC \equiv C^- < NH_2^- < R^-$

(b) $RCOO^- < HC \equiv C^- < R^- < NH_2^-$

(c) $R^- < HC \equiv C^- < RCOO^- < NH_2^-$

(d) $RCOO^- < NH_2^- < HC \equiv C^- < R^-$ *(2010)*

31. Solid $Ba(NO_3)_2$ is gradually dissolved in a 1.0×10^{-4} M Na_2CO_3 solution. At what concentration of Ba^{2+} will a precipitate begin to form?(K_{sp} for $BaCO_3 = 5.1 \times 10^{-9}$)

(a) 4.1×10^{-5} M (b) 5.1×10^{-5} M

(c) 8.1×10^{-8} M (d) 8.1×10^{-7} M *(2009)*

32. Four species are listed below :

(i) HCO_3^- (ii) H_3O^+

(iii) HSO_4^- (iv) HSO_3F

Which one of the following is the correct sequence of their acid strength?

(a) iii < i < iv < ii (b) iv < ii < iii < i
(c) ii < iii < i < iv (d) i < iii < ii < iv *(2008)*

33. The pK_a of a weak acid, (HA), is 4.80. The pK_b of a weak base, BOH is 4.78. The pH of an aqueous solution of the corresponding salt, BA, will be
(a) 9.22 (b) 9.58 (c) 4.79 (d) 7.01
(2008)

34. For the following three reactions (i), (ii) and (iii), equilibrium constants are given
(i) $CO_{(g)} + H_2O_{(g)} \rightleftharpoons CO_{2(g)} + H_{2(g)}$; K_1
(ii) $CH_{4(g)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + 3H_{2(g)}$; K_2
(iii) $CH_{4(g)} + 2H_2O_{(g)} \rightleftharpoons CO_{2(g)} + 4H_{2(g)}$; K_3
Which of the following relation is correct?
(a) $K_3 \cdot K_2^3 = K_1^2$ (b) $K_1\sqrt{K_2} = K_3$
(c) $K_2 K_3 = K_1$ (d) $K_3 = K_1K_2$ *(2008)*

35. The equilibrium constants K_{p_1} and K_{p_2} for the reactions $X \rightleftharpoons 2Y$ and $Z \rightleftharpoons P + Q$, respectively are in the ratio of 1 : 9. If degree of dissociation of X and Z be equal then the ratio of total pressures at these equilibria is
(a) 1 : 9 (b) 1 : 36 (c) 1 : 1 (d) 1 : 3
(2008)

36. In a saturated solution of the sparingly soluble strong electrolyte $AgIO_3$ (molecular mass = 283) the equilibrium which sets in is
$AgIO_{3(s)} \rightleftharpoons Ag^+_{(aq)} + IO^-_{3(aq)}$.
If the solubility product constant K_{sp} of $AgIO_3$ at a given temperature is 1.0×10^{-8}, what is the mass of $AgIO_3$ contained in 100 mL of its saturated solution?
(a) 1.0×10^{-4} g (b) 28.3×10^{-2} g
(c) 2.83×10^{-3} g (d) 1.0×10^{-7} g *(2007)*

37. The pK_a of a weak acid (HA) is 4.5. The pOH of an aqueous bufferd solution of HA in which 50% of the acid is ionized is
(a) 7.0 (b) 4.5 (c) 2.5 (d) 9.5 *(2007)*

38. The first and second dissociation constants of an acid H_2A are 1.0×10^{-5} and 5.0×10^{-10} respectively. The overall dissociation constant of the acid will be
(a) 0.2×10^5 (b) 5.0×10^{-5}
(c) 5.0×10^{15} (d) 5.0×10^{-15} *(2007)*

39. Given the data at 25°C,
$Ag + I^- \rightarrow AgI + e^-$; $E° = 0.152$ V
$Ag \rightarrow Ag^+ + e^-$; $E° = -0.800$ V
What is the value of log K_{sp} for AgI?

$$\left(2.303\frac{RT}{F} = 0.059 \text{ V}\right)$$

(a) −8.12 (b) +8.612 (c) −37.83 (d) −16.13
(2006)

40. The equilibrium constant for the reaction,

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

is $K_c = 4.9 \times 10^{-2}$. The value of K_c for the reaction
$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$ will be
(a) 416 (b) 2.40×10^{-3}
(c) 9.8×10^{-2} (d) 4.9×10^{-2} *(2006)*

41. Phosphorus pentachloride dissociates as follows in a closed reaction vessel,

$$PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$$

If total pressure at equilibrium of the reaction mixture is P and degree of dissociation of PCl_5 is x, the partial pressure of PCl_3 will be

(a) $\left(\frac{x}{x+1}\right)P$ (b) $\left(\frac{2x}{1-x}\right)P$ (c) $\left(\frac{x}{x-1}\right)P$ (d) $\left(\frac{x}{1-x}\right)P$
(2006)

42. An amount of solid NH_4HS is placed in a flask already containing ammonia gas at a certain temperature and 0.50 atm. pressure. Ammonium hydrogen sulphide decomposes to yield NH_3 and H_2S gases in the flask. When the decomposition reaction reaches equilibrium, the total pressure in the flask rises to 0.84 atm. The equilibrium constant for NH_4HS decomposition at this temperature is
(a) 0.30 (b) 0.18 (c) 0.17 (d) 0.11
(2005)

43. Among the following acids which has the lowest pK_a value?
(a) CH_3COOH (b) $(CH_3)_2CH-COOH$
(c) HCOOH (d) CH_3CH_2COOH *(2005)*

44. What is the conjugate base of OH^-?
(a) O_2 (b) H_2O (c) O^- (d) O^{2-}
(2005)

45. Hydrogen ion concentration in mol/L in a solution of pH = 5.4 will be
(a) 3.98×10^8 (b) 3.88×10^6
(c) 3.68×10^{-6} (d) 3.98×10^{-6} *(2005)*

46. For the reaction,
$2NO_{2(g)} \rightleftharpoons 2NO_{(g)} + O_{2(g)}$
($K_c = 1.8 \times 10^{-6}$ at 184°C, $R = 0.0831$ kJ/(mol.K)).
When K_p and K_c are compared at 184°C it is found that
(a) K_p is greater than K_c (b) K_p is less than K_c
(c) $K_p = K_c$
(d) whether K_p is greater than, less than or equal to K_c depends upon the total gas pressure.
(2005)

47. The exothermic formation of ClF_3 is represented by the equation:
$Cl_{2(g)} + 3F_{2(g)} \rightleftharpoons 2ClF_{3(g)}$; $\Delta H = -329$ kJ
Which of the following will increase the quantity of ClF_3 in an equilibrium mixture of Cl_2, F_2 and ClF_3?
(a) Increasing the temperature
(b) Removing Cl_2
(c) Increasing the volume of the container
(d) Adding F_2 *(2005)*

48. The solubility product of a salt having general formula MX_2, in water is 4×10^{-12}. The concentration of M^{2+} ions in the aqueous solution of the salt is
(a) 2.0×10^{-6} M (b) 1.0×10^{-4} M
(c) 1.6×10^{-4} M (d) 4.0×10^{-10} M *(2005)*

49. Consider an endothermic reaction $X \rightarrow Y$ with the activation energies E_b and E_f for the backward and forward reactions, respectively. In general

(a) $E_b < E_f$ (b) $E_b > E_f$
(c) $E_b = E_f$
(d) there is no definite relation between E_b and E_f. *(2005)*

50. The molar solubility (in mol L^{-1}) of a sparingly soluble salt MX_4 is s. The corresponding solubility product is K_{sp}. s is given in terms of K_{sp} by the relation
(a) $s = (K_{sp}/128)^{1/4}$ (b) $s = (128K_{sp})^{1/4}$
(c) $s = (256K_{sp})^{1/5}$ (d) $s = (K_{sp}/256)^{1/5}$ *(2004)*

51. The equilibrium constant for the reaction,
$N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$
at temperature T is 4×10^{-4}. The value of K_c for the reaction :
$NO_{(g)} \rightleftharpoons \frac{1}{2}N_{2(g)} + \frac{1}{2}O_{2(g)}$ at the same temperature is
(a) 2.5×10^2 (b) 50
(c) 4×10^{-4} (d) 0.02 *(2004)*

52. For the reaction, $CO_{(g)} + Cl_{2(g)} \rightleftharpoons COCl_{2(g)}$, the K_p/K_c is equal to
(a) $1/RT$ (b) RT (c) $\sqrt{RT}$ (d) 1.0
(2004)

53. What is the equilibrium expression for the reaction
$P_{4\,(s)} + 5O_{2\,(g)} \rightleftharpoons P_4O_{10\,(s)}$?
(a) $K_c = \dfrac{[P_4O_{10}]}{[P_4][O_2]^5}$ (b) $K_c = \dfrac{[P_4O_{10}]}{5[P_4][O_2]}$
(c) $K_c = [O_2]^5$ (d) $K_c = \dfrac{1}{[O_2]^5}$ *(2004)*

54. The conjugate base of $H_2PO_4^-$ is
(a) PO_4^{3-} (b) P_2O_5 (c) H_3PO_4 (d) HPO_4^{2-}
(2004)

55. When rain is accompanied by a thunderstorm, the collected rain water will have a pH value
(a) slightly lower than that of rain water without thunderstorm
(b) slightly higher than that when the thunderstorm is not there
(c) uninfluenced by occurrence of thunderstorm
(d) which depends on the amount of dust in air. *(2003)*

56. Which one of the following statements is not true?
(a) The conjugate base of $H_2PO_4^-$ is HPO_4^{2-}.
(b) pH + pOH = 14 for all aqueous solutions.
(c) The pH of 1×10^{-8} M HCl is 8.
(d) 96,500 coulombs of electricity when passed through a $CuSO_4$ solution deposits 1 gram equivalent of copper at the cathode. *(2003)*

57. The correct relationship between free energy change in a reaction and the corresponding equilibrium constant K_c is
(a) $\Delta G = RT \ln K_c$ (b) $-\Delta G = RT \ln K_c$
(c) $\Delta G^\circ = RT \ln K_c$ (d) $-\Delta G^\circ = RT \ln K_c$ *(2003)*

58. The solubility in water of a sparingly soluble salt AB_2 is 1.0×10^{-5} mol L^{-1}. Its solubility product will be
(a) 4×10^{-15} (b) 4×10^{-10}
(c) 1×10^{-15} (d) 1×10^{-10} *(2003)*

59. For the reaction equilibrium, $N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$
the concentrations of N_2O_4 and NO_2 at equilibrium are 4.8×10^{-2} and 1.2×10^{-2} mol L^{-1} respectively. The value of K_c for the reaction is
(a) 3.3×10^2 mol L^{-1} (b) 3×10^{-1} mol L^{-1}
(c) 3×10^{-3} mol L^{-1} (d) 3×10^3 mol L^{-1} *(2003)*

60. Consider the reaction equilibrium:
$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$; $\Delta H^\circ = -198$ kJ.
On the basis of Le Chatelier's principle, the condition favourable for the forward reaction is
(a) lowering of temperature as well as pressure
(b) increasing temperature as well as pressure
(c) lowering the temperature and increasing the pressure
(d) any value of temperature and pressure. *(2003)*

61. In which of the following reactions, increase in the volume at constant temperature does not affect the number of moles at equilibrium?
(a) $2NH_3 \rightarrow N_2 + 3H_2$ (b) $C_{(g)} + (1/2)\,O_{2(g)} \rightarrow CO_{(g)}$
(c) $H_{2(g)} + O_{2(g)} \rightarrow H_2O_{2(g)}$ (d) None of these. *(2002)*

62. Change in volume of the system does not alter the number of moles in which of the following equilibria?
(a) $N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$
(b) $PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$
(c) $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$
(d) $SO_2Cl_{2(g)} \rightleftharpoons SO_{2(g)} + Cl_{2(g)}$ *(2002)*

63. For the reaction
$CO_{(g)} + (1/2)\,O_{2(g)} = CO_{2(g)}$, K_p/K_c is
(a) RT (b) $(RT)^{-1}$ (c) $(RT)^{-1/2}$ (d) $(RT)^{1/2}$
(2002)

64. Let the solubility of an aqueous solution of $Mg(OH)_2$ be x then its K_{sp} is
(a) $4x^3$ (b) $108x^5$ (c) $27x^4$ (d) $9x$ 2002)

65. Species acting as both Bronsted acid and base is
(a) $(HSO_4)^-$ (b) Na_2CO_3
(c) NH_3 (d) OH^- *(2002)*

66. 1 M NaCl and 1 M HCl are present in an aqueous solution. The solution is
(a) not a buffer solution with pH < 7
(b) not a buffer solution with pH > 7
(c) a buffer solution with pH < 7
(d) a buffer solution with pH > 7. *(2002)*

ANSWER KEY

1. (b)	**2.** (c)	**3.** (d)	**4.** (b)	**5.** (a)	**6.** (b)	**7.** (d)	**8.** (a)	**9.** (d)	**10.** (a)	**11.** (d)	**12.** (d)
13. (d)	**14.** (c)	**15.** (c)	**16.** (a)	**17.** (d)	**18.** (b)	**19.** (c)	**20.** (c)	**21.** (c)	**22.** (a)	**23.** (c)	**24.** (b)
25. (a)	**26.** (c)	**27.** (b)	**28.** (c)	**29.** (d)	**30.** (a)	**31.** (b)	**32.** (d)	**33.** (d)	**34.** (d)	**35.** (b)	**36.** (c)
37. (d)	**38.** (d)	**39.** (d)	**40.** (a)	**41.** (a)	**42.** (d)	**43.** (b)	**44.** (d)	**45.** (d)	**46.** (a)	**47.** (d)	**48.** (b)
49. (a)	**50.** (d)	**51.** (b)	**52.** (a)	**53.** (d)	**54.** (d)	**55.** (a)	**56.** (c)	**57.** (d)	**58.** (c)	**59.** (c)	**60.** (c)
61. (d)	**62.** (a)	**63.** (c)	**64.** (a)	**65.** (a)	**66.** (a)						

Explanations

1. **(b) :** $H_2S \rightleftharpoons H^+ + HS^-;\ k_1 = 1.0 \times 10^{-7}$
$HS^- \rightleftharpoons H^+ + S^{2-};\ k_2 = 1.2 \times 10^{-13}$
$H_2S \rightleftharpoons S^{2-} + 2H^+$
$K = k_1 \times k_2 = 1.0 \times 10^{-7} \times 1.2 \times 10^{-13} = 1.2 \times 10^{-20}$

$$K = \frac{[S^{2-}][H^+]^2}{[H_2S]} = 1.2\times10^{-20};\ [S^{2-}] = \frac{1.2\times10^{-20}\times[H_2S]}{[H^+]^2}$$

$[H_2S] = 0.1$ M
$[HCl] = 0.2$ M
As HCl is stronger acid so, $[H^+] = 0.2$ M

$$[S^{2-}] = \frac{1.2\times10^{-20}\times0.1}{(0.2)^2} = 3 \times 10^{-20}\text{ M}$$

2. **(c) :** (Na_2SO_4) $(BaSO_4)$
$M_1V_1 = M_2V_2$
$1\text{ M} \times 50 = M_2 \times 500$

$$M_2 = \frac{50}{500} = \frac{1}{10}$$

For just precipitation, $Q_{sp} = K_{sp}$; $[Ba^{2+}]\,[SO_4^{2-}] = K_{sp}(BaSO_4)$

$$Ba^{2+} \times \frac{1}{10} = 10^{-10} \Rightarrow Ba^{2+} = 10^{-9}\text{ M in 500 mL}$$

Initially, $[Ba^{2+}]$ in original solution (450 mL)
$M_1 \times 450 = 10^{-9} \times 500$

$$M_1 = \frac{500\times10^{-9}}{450} = 1.1\times10^{-9}\text{ M}$$

3. **(d) :** The compound which can accept a pair of electrons is known as Lewis acid. BCl_3 and $AlCl_3$ have vacant orbitals and their octet is not complete thus these can accept electron pairs and behave as Lewis acids.

4. **(b) :** $Al(CN)_3 + H_2O \rightleftharpoons \underset{\text{Weak base}}{Al(OH)_3} + \underset{\text{Weak acid}}{HCN}$

$CH_3COOK + H_2O \rightleftharpoons \underset{\text{Weak acid}}{CH_3COOH} + \underset{\text{Strong base}}{KOH}$

$FeCl_3 + H_2O \rightleftharpoons \underset{\text{Weak base}}{Fe(OH)_3} + \underset{\text{Strong acid}}{HCl}$

$Pb(CH_3COO)_2 \rightleftharpoons \underset{\text{Weak base}}{Pb(OH)_2} + \underset{\text{Weak acid}}{CH_3COOH}$

Hence, for the CH_3COOK, nature of solution is basic.

5. **(a) :** According to Boyle's law : $\text{Pressure} \propto \frac{1}{\text{Volume}}$

i.e., when volume of the container is increased, the pressure decreases. To undo the effect of decreased pressure, the reaction will move in a direction where pressure increases *i.e.*, towards the greater moles of gaseous substances. This is in accordance with Le Chatelier's principle.

6. **(b) :** $PbCl_2 \rightleftharpoons \underset{s}{Pb^{2+}} + \underset{2s}{2Cl^-}$ (s = solubility of $PbCl_2$)
$K_{sp} = [Pb^{2+}]\,[Cl^-]^2$
$3.2 \times 10^{-8} = s \times (2s)^2 = 4s^3 \Rightarrow s = 2 \times 10^{-3}$ M

$$\text{Solubility} = \frac{n_{PbCl_2}}{\text{Volume (in L)}}$$

$$s = \frac{0.1}{278}\times\frac{1}{V} = 2\times10^{-3} \Rightarrow V = \frac{0.1}{278}\times\frac{10^3}{2} = 0.1798 \simeq 0.18\text{ L}$$

7. **(d)**

8. **(a) :** $NaOH + HCl \longrightarrow NaCl + H_2O$
(a) 25 mL NaOH will react will 25 mL HCl
Total volume of solution = 75 + 25 = 100 mL

$$\text{Millimoles of HCl left} = \frac{75}{5} - \frac{25}{5} = 10$$

$$\text{Concentration of HCl} = \frac{\text{Millimoles}}{\text{Volume}} = \frac{10}{100} = 0.1\text{M}$$

$pH = -\log[H^+] = -\log[0.1] = 1$
(b) This will be a neutral solution *i.e.*, pH = 7

$$\text{(c) Millimoles of HCl left} = \frac{55}{10} - \frac{45}{10} = 5.5 - 4.5 = 1$$

$$\text{Concentration of HCl} = \frac{1}{100} = 0.01\text{ M}$$

$\therefore$ pH = 2

$$\text{(d) Millimoles of HCl left} = \frac{60}{10} - \frac{40}{10} = 6 - 4 = 2$$

$$\text{Concentration of HCl} = \frac{2}{100} = 0.02\text{ M}$$

$\therefore$ pH = 1.69

9. **(d) :**

	CO +	Cl_2 $\rightleftharpoons$	$COCl_2$
Initial moles	2	3	0
At equil.	1	2	1

$$K_c = \frac{[COCl_2]}{[CO][Cl_2]} = \frac{\frac{1}{5}}{\left(\frac{1}{5}\right)\left(\frac{2}{5}\right)} = \frac{5}{2} = 2.5$$

10. **(a) :**

	$A_{2(g)}$ $\rightleftharpoons$	$2A_{(g)}$
Pressure at $t = 0$	1 atm	0
At eq.	$1 - \frac{20}{100} = 0.8$ atm	$2\times\frac{20}{100} = 0.4$ atm

$$\text{Equilibrium constant, } K_p = \frac{(p_A)^2}{p_{A_2}} = \frac{(0.4)^2}{0.8} = 0.2$$

$\Delta G^\circ = -2.303\,RT\log K_p = -2.303 \times 8.314 \times 320 \log 0.2 = 4282.64\text{ J mol}^{-1}$

11. **(d) :** $2NO_{2(g)} \longrightarrow N_2O_{4(g)}$; $\Delta H = -ve$

According to Le-Chatelier's principle, when inert gas is added at constant pressure, the total volume increases which leads to decrease in molar concentration of reactant and product. Thus, the reaction moves towards backward direction and decomposition of N_2O_4 increases. Addition of inert gas at constant volume does not affect equilibrium.
On increasing the pressure, the reaction moves towards forward direction (lesser moles).
On lowering temperature, the reaction moves to forward direction as it is an exothermic reaction.

12. **(d) :** pH of a salt of a weak acid and a weak base is given by :

$$pH = 7 + \frac{1}{2}(pK_a - pK_b) = 7 + \frac{1}{2}(3.2 - 3.4) = 6.9$$

13. **(d) :** $HA \longrightarrow H^+ + A^-$

$$K_a = \frac{[H^+][A^-]}{[HA]} = 10^{-5}\ ;\ pH = pK_a + \log\frac{[\text{Salt}]}{[\text{Acid}]}$$

$6 = -\log[10^{-5}] + \log\frac{[\text{Salt}]}{[\text{Acid}]} \Rightarrow 6 = 5 + \log\frac{[\text{Salt}]}{[\text{Acid}]}$

$\frac{[\text{Salt}]}{[\text{Acid}]} = \text{Antilog } 1 = 10$

[Salt] : [Acid] = 10 : 1

14. (c) :

	NH_3	+ $HCl \longrightarrow$	NH_4Cl
Initial	$\frac{50\times0.2}{1000}$	$\frac{25\times0.2}{1000}$	
After reaction :	= 10	= 5	0
Buffer solution :	5	0	5

$pOH = pK_b + \log\frac{[\text{salt}]}{[\text{base}]} = 4.75$

$pH = 14 - 4.75 = 9.25$

15. (c) :

	A	+ $B \rightleftharpoons$	C	+ D
Initial conc.	1	1	1	1
At equilibrium	$1-x$	$1-x$	$1+x$	$1+x$

$$\text{V\{} \quad 1\ h \quad = \frac{\text{gYi ga i}}{\text{gWgXi}} \Rightarrow 655 = \frac{\text{-6+ .}^7}{\text{-6− .}^7} \Rightarrow 65 = \frac{6+}{6-}$$

$10 - 10x = 1 + x \Rightarrow 9 = 11x \Rightarrow x = 0.818$

So, concentration of D at equilibrium = 1 + 0.818 = 1.818 M

16. (a) : $XY_{(s)} \rightleftharpoons X_{(g)} + Y_{(g)}$

$K_p = (p_X)\,(p_Y)$

$p_X = x_X \times P_{\text{Total}} = \frac{1}{2} \times 10 = 5 \text{ bar}$

Similarly, $p_Y = \frac{1}{2} \times 10 = 5 \text{ bar}$

Now, $K_p = 5 \times 5 = 25$

17. (d) : $2A \rightleftharpoons B + C$

Given : $T = 300$ K, $\Delta G° = 2494.2$ J, $R = 8.314$ JK^{-1} mol^{-1}

$\Delta G° = -2.303\ RT \log K_c$

$2494.2 = -2.303 \times 8.314 \times 300 \times \log K_c$

$\log K_c = \text{antilog}(-0.4342) \Rightarrow K_c = 0.3679$

$$n \quad = \frac{\text{gXigYi}}{\text{gWi}^7} = \frac{7\times\frac{6}{7}}{\left(\frac{6}{7}\right)^7} = 9$$

Here, $Q_c > K_c$ thus, the reaction will proceed in the backward direction.

18. (b) :

	$N_2O_{4(g)} \rightleftharpoons$	$2NO_{2(g)}$
At $t = 0$	1	0
At eqm.	$1-\alpha$	2α

where α is degree of dissociation.

$$\text{Mol. wt. of mixture } (M_{\text{mix.}}) = \frac{\text{-6}-\alpha.\times j \ \ \text{V}_7\text{W}_9 + 7\alpha\times j \ \ \text{VW}_7}{\text{-6}+\alpha.}$$

$$= \frac{\text{-6}-\text{537.}\times\text{>7}+7\times\text{537}\times\text{9;}}{\text{-6}+\text{537.}} = \text{<; 3 ;}$$

Now, as per ideal gas equation, $PV = nRT$

$PM_{\text{mix.}} = dRT$

$$\therefore \quad = \frac{\text{nj} \ \ \text{y u}}{o\,q} = \frac{6\times\text{<; 3 ;}}{\text{535=76}\times855} = \text{8366 s 4S}$$

19. (c) : $A_{(g)} \rightleftharpoons B_{(g)}$; $\Delta H = -40$ kJ/mol

$$\frac{b_{\text{- .}}}{b_{\text{- .}}} = \frac{7}{8}$$

We know that, $E_{a(f)} - E_{a(b)} = \Delta H$

$E_{a(f)} - E_{a(b)} = -40 \Rightarrow \frac{7}{8}b_{\text{- .}} - b_{\text{- .}} = -95$

$E_{a(b)} = 120$ kJ/mol, $E_{a(f)} = 80$ kJ/mol

20. (c) : Ice + Heat $\rightleftharpoons$ Water

More volume Less volume

On increasing the pressure on this system in equilibrium, the equilibrium tends to shift in a direction in which volume decreases, *i.e.*, in the forward direction.

21. (c) : For the reaction, $SO_{2(g)} + \frac{1}{2}O_{2(g)} \rightleftharpoons SO_{3(g)}$

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

where, Δn_g = no. of products$_{(g)}$ – no. of reactants$_{(g)}$

$$= 1 - \left(1 + \frac{1}{2}\right) = -\frac{1}{2} = x$$

22. (a) : Initial concentration of aq. HCl solution with pH 1 = 10^{-1} M

Final concentration of this solution after dilution = 10^{-2} M

$MV = M_1(V_1 + V_2) \Rightarrow 10^{-1} \times 1 = 10^{-2}(1 + V_2)$

$\frac{0.1}{0.01} = 1 + V_2 \Rightarrow 10 = 1 + V_2 \Rightarrow V_2 = 9$ L

23. (c) : $N_{2(g)} + O_{2(g)} \longrightarrow 2NO_{(g)}$, $K_c = 4 \times 10^{-4}$ ... (i)

By multiplying the equation (i) by $\frac{1}{2}$

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

$K'_c = \sqrt{K_c} = \sqrt{4\times10^{-4}} = 2\times10^{-2}$

By reversing the equation (ii), we get $NO_{(g)} \longrightarrow \frac{1}{2}N_{2(g)} + \frac{1}{2}O_{2(g)}$

$K''_c = \frac{1}{K'_c} = \frac{1}{2\times10^{-2}} = 50.0$

24. (b) : pH = 3; Molarity = 0.1 M

$[H^+] = \sqrt{K_aC}$

$H^+ = 10^{-pH} = 10^{-3}$

$10^{-3} = \sqrt{K_a \times 0.1} \Rightarrow 10^{-6} = K_a \times 0.1 \Rightarrow K_a = 10^{-5}$

25. (a) : $CO_{2\,(g)} + C_{(s)} \rightleftharpoons 2CO_{(g)}$

$CO_{2\,(g)}$	$2CO_{(g)}$
0.5 atm	
$0.5 - P$	$2P$

Total pressure = $0.5 - P + 2P = 0.8 \Rightarrow P = 0.3$

$K_P = \frac{P^2_{CO}}{P_{CO_2}} = \frac{(2P)^2}{(0.5-P)} = \frac{(0.6)^2}{(0.5-0.3)} = 1.8$ atm

26. (c) : $(K_{sp})_{Mg(OH)_2} = [Mg^{2+}][OH^-]^2$

$1 \times 10^{-11} = [0.001][OH^-]^2 \Rightarrow [OH^-]^2 = \frac{10^{-11}}{10^{-3}} = 10^{-8} \Rightarrow [OH^-] = 10^{-4}$

pOH = 4

Thus, pH = 14 – 4 = 10

27. (b) : In equation (ii), $H_2PO_4^-$ acts as a proton donor and thus, acts as an acid.

28. (c) : Given, $(K_{sp})_{AgBr} = 5.0 \times 10^{-13}$

The required equation is, $KBr + AgNO_3 \longrightarrow AgBr + KNO_3$

Given, $[AgNO_3] = 0.05$ M; $[Ag^+] = [NO_3^-] = 0.05$ M

$\because \quad [Ag^+][Br^-] = (K_{sp})_{AgBr}$

$\Rightarrow \quad 0.05 \times [Br^-] = 5 \times 10^{-13} \Rightarrow [Br^-] = \frac{5\times10^{-13}}{5\times10^{-2}} = 1\times10^{-11}$ M

$\because\ [K^+] = [Br^-] = [KBr] \Rightarrow [KBr] = 1 \times 10^{-11}$ M

$$\text{Molarity} = \frac{n_{KBr}}{V_{Solution}(L)}$$

$$1 \times 10^{-11} = \frac{w_{KBr}/120}{1} \text{ (Mol. wt. of KBr = 120)}$$

$\Rightarrow w_{KBr} = 1 \times 10^{-11} \times 120 = 120 \times 10^{-11} = 1.2 \times 10^{-9}$ g

29. (d) : $H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$; $K_1 = 4.2 \times 10^{-7}$

$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$; $K_2 = 4.8 \times 10^{-11}$

$\because K_1 >> K_2$, so H_2CO_3 ionises more than HCO_3^- and hence, contribution of H^+ is mostly due to ionisation of carbonic acid, thus the concentrations of H^+ and HCO_3^- are approximately equal.

30. (a) : The order of acidity can be explained on the basis of the acidity of the acids of the given conjugate base. Stronger is the acid, weaker is the conjugate base. Since *R*COOH is the strongest acid amongst all, $RCOO^-$ is the weakest base. Due to *sp* hybridised carbon, acetylene is also acidic and hence a weak base but stronger than $RCOO^-$. As sp^3 carbon is less electronegative than sp^3 nitrogen, R^- is more basic than NH_2^-.

31. (b) : K_{sp} for $BaCO_3 = [Ba^{2+}][CO_3^{2-}]$

given, $[CO_3^{2-}] = 1 \times 10^{-4}$ M (from Na_2CO_3)

$K_{sp} = 5.1 \times 10^{-9}$

$\therefore 5.1 \times 10^{-9} = [Ba^{2+}] \times [10^{-4}] \Rightarrow [Ba^{2+}] = 5.1 \times 10^{-5}$ M

Thus, when $[Ba^{2+}] = 5.1 \times 10^{-5}$ M, $BaCO_3$ precipitate will begin to form.

32. (d) : HSO_3F is the super acid. Its acidic strength is greater than any given species. The pK_a value of other species are given below :

$HCO_3^- \rightarrow 10.25$

$H_3O^+ \rightarrow -1.74$

$HSO_4^- \rightarrow 1.92$

Lesser the pK_a value, higher will be its acidic strength. Hence sequence of acidic strength will be

$HSO_3F > H_3O^+ > HSO_4^- > HCO_3^-$

33. (d) : Given that pK_a = 4.8 and pK_b = 4.78

$\therefore$ pH = 7 + 1/2 (pK_a − pK_b) = 7 + 1/2 (4.80 − 4.78) = 7.01

34. (d) : $CO_{(g)} + H_2O_{(g)} \rightleftharpoons CO_{2(g)} + H_{2(g)}$

$$K_1 = \frac{[CO_2][H_2]}{[CO][H_2O]} \quad \text{...(i)}$$

$CH_{4(g)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + 3H_{2(g)}$

$$K_2 = \frac{[CO][H_2]^3}{[CH_4][H_2O]} \quad \text{...(ii)}$$

$CH_{4(g)} + 2H_2O_{(g)} \rightleftharpoons CO_{2(g)} + 4H_{2(g)}$

$$K_3 = \frac{[CO_2][H_2]^4}{[CH_4][H_2O]^2} \quad \text{...(iv)}$$

From equations (i), (ii) and (iii) ; $K_3 = K_1 \times K_2$

35. (b) :

$$\begin{array}{lccccc} & X \rightleftharpoons & 2Y\ ; & Z \rightleftharpoons & P & +\ Q \\ \text{Initial mol.} & 1 & 0 & 1 & 0 & 0 \\ \text{At equilibrium} & 1-\alpha & 2\alpha & 1-\alpha & \alpha & \alpha \end{array}$$

$$K_{p_1} = \frac{p_Y^2}{p_X} = \frac{\left(\frac{2\alpha}{1+\alpha}p_1\right)^2}{\left(\frac{1-\alpha}{1+\alpha}p_1\right)}$$

$$K_{p_2} = \frac{p_P\, p_Q}{p_Z} = \frac{\left(\frac{\alpha}{1+\alpha}p_2\right)\left(\frac{\alpha}{1+\alpha}p_2\right)}{\left(\frac{1-\alpha}{1+\alpha}p_2\right)}$$

$$\Rightarrow K_{p_1} = \frac{4\alpha^2 p_1}{1-\alpha^2} \quad \text{...(i)} \quad \Rightarrow K_{p_2} = \frac{\alpha^2 p_2}{1-\alpha^2} \quad \text{...(ii)}$$

$$\text{Given is } \frac{K_{p_1}}{K_{p_2}} = \frac{1}{9} \quad \text{...(iii)}$$

Substituting values of from equation (i) and (ii) into (iii), we get

$$\frac{\frac{4\alpha^2 p_1}{1-\alpha^2}}{\frac{\alpha^2 p_2}{1-\alpha^2}} = \frac{1}{9} \Rightarrow \frac{4\,p_1}{p_2} = \frac{1}{9} \Rightarrow \frac{p_1}{p_2} = \frac{1}{36}$$

36. (c) : $AgIO_3 \rightleftharpoons \underset{S}{Ag^+} + \underset{S}{IO_3^-}$ [*S* = Solubility]

$K_{sp} = S^2 \Rightarrow S^2 = 1.0 \times 10^{-8}$

$S = 1.0 \times 10^{-4}$ mol/L

$$= 1.0 \times 10^{-4} \times 283 \text{ g/L} = \frac{1.0 \times 10^{-4} \times 283}{1000} \text{ g/L}$$

$$= \frac{1.0 \times 10^{-4} \times 283 \times 100}{1000} \text{ g/100mL}$$

$= 28.3 \times 10^{-4}$ g/100 mL $= 2.83 \times 10^{-3}$ g/100 mL

37. (d) : For acidic buffer, $\text{pH} = \text{p}K_a + \log\frac{[A^-]}{[HA]}$

When the acid is 50% ionised, $[A^-] = [HA]$

pH = pK_a + log1 $\Rightarrow$ pH = pK_a

Given pK_a = 4.5 ; pH = 4.5

$\therefore$ pOH = 14 − 4.5 = 9.5

38. (d) : $H_2A \rightleftharpoons H^+ + HA^-$;

$$K_1 = \frac{[H^+][HA^-]}{[H_2A]} = 1 \times 10^{-5}$$

$$HA^- \rightleftharpoons H^+ + A^{2-};\ K_2 = 5 \times 10^{-10} = \frac{[H^+][A^{2-}]}{[HA^-]}$$

$$K = \frac{[H^+]^2[A^{2-}]}{[H_2A]} = K_1 \times K_2 = 1 \times 10^{-5} \times 5 \times 10^{-10} = 5 \times 10^{-15}$$

39. (d) : $AgI_{(s)} + e^- \rightarrow Ag_{(s)} + I^-$, $E° = -0.152$ V

$Ag_{(s)} \rightarrow Ag^+ + e^-$, $E° = -0.800$ V

$AgI_{(s)} \rightarrow Ag^+ + I^-$, $E° = -0.952$ V

$$E°_{cell} = \frac{0.059}{n}\log K \Rightarrow -0.952 = \frac{0.059}{1}\log K_{sp}$$

$$\text{or, } \log K_{sp} = -\frac{0.952}{0.059} = -16.135$$

40. (a) : $SO_{3(g)} \rightleftharpoons SO_{2(g)} + 1/2\ O_{2(g)}$

$$\frac{[SO_2][O_2]^{1/2}}{[SO_3]} = K_c = 4.9 \times 10^{-2} \quad \text{... (i)}$$

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

$$\frac{[SO_3]}{[SO_2][O_2]^{1/2}} = K_c' = \frac{1}{4.9 \times 10^{-2}} \quad \text{... (ii)}$$

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

$$\frac{[SO_3]^2}{[SO_2]^2[O_2]} = K_c'^2 = \frac{1}{4.9 \times 4.9 \times 10^{-4}} = \frac{10000}{24.01} = 416.49$$

41. **(a) :** $PCl_{5\,(g)} \rightleftharpoons PCl_{3\,(g)} + Cl_{2\,(g)}$

$$\begin{array}{llll} t = 0 & 1 & 0 & 0 \\ t_{eq} & 1 - x & x & x \end{array}$$

Total number of moles = $1 - x + x + x = 1 + x$

Thus partial pressure of $PCl_3 = \left(\dfrac{x}{1+x}\right)P$

42. **(d) :** $NH_4HS_{(s)} \rightleftharpoons NH_{3(g)} + H_2S_{(g)}$

$$\begin{array}{llll} \text{Initial pressure} & 0 & 0.5 & 0 \\ \text{At equi.} & 0 & 0.5 + x & x \end{array}$$

Total pressure = $0.5 + 2x = 0.84 \Rightarrow x = 0.17$ atm

$K_p = p_{NH_3} \times p_{H_2S} = (0.5 + 0.17)(0.17) = 0.11\ \text{atm}^2$

43. **(b) :** Higher the pK_a value, weaker is the acid. Hence, strongest acid has lowest pK_a value.

44. **(d) :** Conjugate base of OH^- is O^{2-}.

$OH^- \rightleftharpoons O^{2-} + H^+$

45. **(d) :** $pH = -\log[H^+]$

$[H^+]$ = antilog (–pH) = antilog(–5.4) = 3.98×10^{-6}

46. **(a) :** $K_p = K_c(RT)^{\Delta n}$; $\Delta n = 3 - 2 = 1$

$K_p = K_c(0.0831 \times 457)^1$

$\therefore \quad K_p > K_c$

47. **(d) :** $Cl_{2(g)} + 3F_{2(g)} \rightleftharpoons 2ClF_{3(g)}$; $\Delta H = -329$ kJ

Favourable conditions:

(i) As the reaction is exothermic, hence decrease in temperature will favour the forward reaction.

(ii) Addition of reactants or removal of product will favour the forward reaction.

(iii) Here $\Delta n = 2 - 4 = -2$ (*i.e.*, –ve) hence decrease in volume or increase in pressure will favour the forward reaction.

48. **(b) :** $MX_{2(s)} \rightleftharpoons \underset{s}{M^{2+}_{(aq)}} + \underset{2s}{2X^-_{(aq)}}$

$K_{sp} = s \cdot (2s)^2 = 4s^3 \Rightarrow 4 \times 10^{-12} = 4s^3 \Rightarrow s^3 = 1 \times 10^{-12}$

$\Rightarrow s = 1 \times 10^{-4}\ M \Rightarrow [M^{2+}] = 1 \times 10^{-4}\ M$

49. **(a) :** For endothermic reaction, ΔH = +ve

$\Rightarrow \Delta H = E_f - E_b$, it means $E_b < E_f$

50. **(d) :** $MX_4\ (\text{solid}) \rightleftharpoons \underset{s}{M^{4+}_{(aq)}} + \underset{4s}{4X^-_{(aq)}}$

Solubility product, $K_{sp} = s \times (4s)^4 = 256\ s^5$.

$$\therefore \quad s = \sqrt[5]{\frac{K_{sp}}{256}} = \left(\frac{K_{sp}}{256}\right)^{1/5}$$

51. **(b) :** $N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$

$$K_c = \frac{[NO]^2}{[N_2][O_2]} = 4 \times 10^{-4}$$

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

$$K_c' = \frac{[N_2]^{1/2}[O_2]^{1/2}}{[NO]} = \frac{1}{\sqrt{K_c}} = \frac{1}{\sqrt{4 \times 10^{-4}}} = \frac{1}{2 \times 10^{-2}} = \frac{100}{2} = 50$$

52. **(a) :** $CO_{(g)} + Cl_{2(g)} \rightleftharpoons COCl_{2(g)}$

$\Delta n = 1 - 2 = -1$

$$K_p = K_c(RT)^{\Delta n} \Rightarrow \frac{K_p}{K_c} = (RT)^{-1} = \frac{1}{RT}$$

53. **(d) :** $P_{4\,(s)} + 5O_{2\,(g)} \rightleftharpoons P_4O_{10\,(s)}$

$$K_c = \frac{[P_4O_{10\,(s)}]}{[P_{4\,(s)}][O_{2(g)}]^5}$$

We know that concentration of a solid component is always taken as unity.

$$K_c = \frac{1}{[O_2]^5}$$

54. **(d) :** Conjugate base is formed by the removal of H^+ from acid. $H_2PO_4^- \rightarrow HPO_4^{2-} + H^+$

55. **(a) :** Due to thunderstorm, temperature increases. As temperature increases, $[H^+]$ also increases, hence pH decreases.

56. **(c) :** pH of an acid cannot exceed 7. Here we should also consider $[H^+]$ that comes from H_2O.

Now $[H^+] = [H^+]_{\text{from HCl}} + [H^+]_{\text{from }H_2O}$

$= 10^{-8} + 10^{-7} = 10^{-8} + 10 \times 10^{-8} = 11 \times 10^{-8}$

$\therefore \quad pH = -\log(11 \times 10^{-8}) = 6.9587$

57. **(d) :** $\Delta G = \Delta G^\circ + 2.303\ RT \log K_c$

At equilibrium, $\Delta G = 0$

$\Delta G^\circ = -2.303\ RT \log K_c$

58. **(c) :** $AB_2 \rightleftharpoons A^{2+} + 2B^-$

$S = 1.0 \times 10^{-5}\ \text{mol L}^{-1}$

$K_{sp} = [A^{2+}][B^-]^2 = 1.0 \times 10^{-5} \times (1.0 \times 10^{-5})^2 = 1.0 \times 10^{-15}$

59. **(c) :** $[N_2O_4] = 4.8 \times 10^{-2}\ \text{mol L}^{-1}$; $[NO_2] = 1.2 \times 10^{-2}\ \text{mol L}^{-1}$

$$K_c = \frac{[NO_2]^2}{[N_2O_4]} = \frac{1.2 \times 10^{-2} \times 1.2 \times 10^{-2}}{4.8 \times 10^{-2}} = 0.3 \times 10^{-2} = 3 \times 10^{-3}\ \text{mol L}^{-1}$$

60. **(c) :** The conversion of SO_2 to SO_3 is an exothermic reaction, hence decrease the temperature will favour the forward reaction. There is also a decrease in volume or moles in product side. Thus the reaction is favoured by low temperature and high pressure. (Le Chatelier's principle).

61. **(d) :** For those reactions, where $\Delta n = 0$, increase in volume at constant temperature does not affect the number of moles at equilibrium.

62. **(a) :** In this reaction the ratio of number of moles of reactants to products is same *i.e.* 2 : 2, hence change in volume will not alter the number of moles.

63. **(c) :** $K_p = K_c(RT)^{\Delta n}$; $\Delta n = 1 - \left(1 + \frac{1}{2}\right) = 1 - \frac{3}{2} = -\frac{1}{2}$

$$\therefore \quad \frac{K_p}{K_c} = (RT)^{-1/2}$$

64. **(a) :** $Mg(OH)_2 \rightarrow \underset{x}{[Mg^{2+}]} + \underset{2x}{2[OH^-]}$

$K_{sp} = [Mg^{2+}][OH^-]^2 \Rightarrow K_{sp} = (x) \times (2x)^2 = x \times 4x^2 = 4x^3$

65. **(a) :** According to Bronsted-Lowry concept, a Bronsted acid is a substance which can donate a proton to any other substance and a Bronsted base is a substance which can accept a proton from any other substance.

$(HSO_4)^-$ can accept and donate a proton.

$(HSO_4)^- + H^+ \rightarrow H_2SO_4$

$(HSO_4)^- - H^+ \rightarrow SO_4^{2-}$

66. **(a) :** HCl is a strong acid and its salt do not form bufter solution. As the resultant solution is acidic, hence pH is less than 7.