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EQUILIBRIUM

SET:02
EXERCISE-I

EQUILIBRIUM

CHEMICAL EQUILIBRIUM
Properties of equilibrium, active mass, homogeneous & heterogeneous equilibrium (theoritical)

Q.1 In chemical reaction $A \rightleftharpoons B$, the system will be known in equilibrium when
(1) A completely changes to B
(2) 50% of A changes to B
(3) The rate of change of A to B and B to A on both the sides are same
(4) Only 10% of A changes to B

Q.2 If a system is at equilibrium the rate of forward to the reverse reaction is
(1) Less
(2) Equal
(3) High
(4) At equilibrium

Q.3 The active mass of 64 gm of HI in a two litre flask would be
(1) 2   (2) 1
(3) 5   (4) 0.25

Q.4 Under a given set of experimental conditions, with increase in the concentration of the reactants, the rate of a chemical reaction
(1) Decreases
(2) Increases
(3) Remains unaltered
(4) First decreases and then increases

Q.5 Theory of 'active mass' indicates that the rate of chemical reaction is directly proportional to the
(1) Equilibrium constant
(2) Properties of reactants
(3) Volume of apparatus
(4) Concentration of reactants

Q.6 Which is false
(1) The greater the concentration of the substances involved in a reaction, the lower the speed of the reaction
(2) The point of dynamic equilibrium is reached when the reaction rate in one direction just balances the reaction rate in the opposite direction
(3) The dissociation of weak electrolyte is a reversible reaction
(4) The presence of free ions facilitates chemical changes

Homogeneous equilibrium : K_C

Q.7 For the system $3A + 2B \rightleftharpoons C$, the expression for equilibrium constant is
(1) $\dfrac{[3A][2B]}{C}$ (2) $\dfrac{[C]}{[3A][2B]}$
(3) $\dfrac{[A]^3[B]^2}{[C]}$ (4) $\dfrac{[C]}{[A]^3[B]^2}$

Q.8 In the reversible reaction $A + B \rightleftharpoons C + D$, the concentration of each C and D at equilibrium was 0.8 mole/litre, then the equilibrium constant K_c will be
(1) 6.4   (2) 0.64   (3) 1.6   (4) 16.0

Q.9 4 moles of A are mixed with 4 moles of B. At equilibrium for the reaction $A + B \rightleftharpoons C + D$, 2 moles of C and D are formed. The equilibrium constant for the reaction will be
(1) $\dfrac{1}{4}$ (2) $\dfrac{1}{2}$ (3) 1   (4) 4

Q.10 For the system $A(g) + 2B(g) \rightleftharpoons C(g)$, the equilibrium concentrations of (A) = 0.06 mole/litre, (B) = 0.12 mole/litre, (C) = 0.216 mole/litre. The K_{eq} for the reaction is
(1) 250   (2) 416   (3) 4×10^{-3} (4) 125

Q.11 Partial pressures of A, B, C and D on the basis of gaseous system $A + 2B \rightleftharpoons C + 3D$ are A = 0.20; B = 0.10; C = 0.30 and D = 0.50 atm. The numerical value of equilibrium constant is
(1) 11.25   (2) 18.75   (3) 5   (4) 3.75

Q.12 For the reaction $A + 2B \rightleftharpoons C$, the expression for equilibrium constant is
(1) $\dfrac{[A][B]^2}{[C]}$ (2) $\dfrac{[A][B]}{[C]}$ (3) $\dfrac{[C]}{[A][B]^2}$ (4) $\dfrac{[C]}{2[B][A]}$

Q.13 2 moles of PCl_5 were heated in a closed vessel of 2 litre capacity. At equilibrium, 40% of PCl_5 is dissociated into PCl_3 and Cl_2. The value of equilibrium constant is
(1) 0.266   (2) 0.53   (3) 2.66   (4) 5.3

Q.14 Unit of equilibrium constant for the reversible reaction $H_2 + I_2 \rightleftharpoons 2HI$ is
(1) mol^{-1} litre
(2) mol^{-2} litre
(3) $mol\ litre^{-1}$
(4) None of these

Q.15 In a reaction $A + B \rightleftharpoons C + D$, the concentrations of A, B, C and D (in moles/litre) are 0.5, 0.8, 0.4 and 1.0 respectively. The equilibrium constant is
(1) 0.1   (2) 1.0   (3) 10   (4) ∞

Homogeneous equilibrium : K_P

Q.16 At 3000 K the equilibrium pressures of CO_2, CO and O_2 are 0.6, 0.4 and 0.2 atmospheres respectively. K_p for the reaction, $2CO_2 \rightleftharpoons 2CO + O_2$ is
(1) 0.089   (2) 0.0533
(3) 0.133   (4) 0.177

Q.17 Calculate the partial pressure of carbon monoxide from the following
$$CaCO_{3(s)} \xrightarrow{\Delta} CaO_{(s)} + CO_2 \uparrow; \quad K_p = 8 \times 10^{-2}$$
$$CO_{2(g)} + C_{(s)} \to 2CO_{(g)} ; \quad K_p = 2$$
(1) 0.2   (2) 0.4   (3) 1.6   (4) 4

Q.18 For the reaction : $H_{2(g)} + CO_{2(g)} \rightleftharpoons CO_{(g)} + H_2O_{(g)}$, if the initial concentration of $[H_2] = [CO_2]$ and x moles/litre of hydrogen is consumed at equilibrium, the correct expression of K_p is
(1) $\dfrac{x^2}{(1-x)^2}$ (2) $\dfrac{(1+x)^2}{(1-x)^2}$ (3) $\dfrac{x^2}{(2+x)^2}$ (4) $\dfrac{x^2}{1-x^2}$

Q.19 For the reaction $C(s) + CO_2(g) \rightleftharpoons 2CO(g)$, the partial pressure of CO_2 and CO are 2.0 and 4.0 atm respectively at equilibrium. The K_p for the reaction is
(1) 0.5   (2) 4.0   (3) 8.0   (4) 32.0

Q.20 $CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$ which of the following expression is correct
(1) $K_P = (P_{CaO} + P_{CO_2} / P_{CaCO_3})$
(2) $K_P = P_{CO_2}$
(3) $K_P \times (P_{CaO} \times P_{CO_2}).P_{CaCO_3}$
(4) $\dfrac{K_p[CaO][CO_2]}{[CaCO_3]}$

Relation between K_P and K_C

Q.21 In which of the following reaction, the value of K_p will be equal to K_c
(1) $H_2 + I_2 \rightleftharpoons 2HI$
(2) $PCl_5 \rightleftharpoons PCl_3 + Cl_2$
(3) $2NH_3 \rightleftharpoons N_2 + 3H_2$
(4) $2SO_2 + O_2 \rightleftharpoons 2SO_3$

Q.22 The relation between equilibrium constant K_p and K_c is
(1) $K_c = K_p (RT)^{\Delta n}$ (2) $K_p = K_c (RT)^{\Delta n}$
(3) $K_p = \left(\dfrac{K_c}{RT}\right)^{\Delta n}$ (4) $K_p - K_c = (RT)^{\Delta n}$

Q.23 For $N_2 + 3H_2 \rightleftharpoons 2NH_3$ + heat
(1) $K_p = K_c(RT)$ (2) $K_p = K_c(RT)$
(3) $K_p = K_c (RT)^{-2}$ (4) $K_p = K_c (RT)^{-1}$

Q.24 In which of the following equilibria, the value of K_p is less than K_c
(1) $H_2 + I_2 \rightleftharpoons 2HI$
(2) $N_2 + 3H_2 \rightleftharpoons 2NH_3$
(3) $N_2 + O_2 \rightleftharpoons 2NO$
(4) $CO + H_2O \rightleftharpoons CO_2 + H_2$

Q.25 For which of the following reactions $K_p = K_c$
(1) $2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$
(2) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
(3) $H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$
(4) $N_2O_4(g) \rightleftharpoons 2NO_2(g)$

Q.26 For the reaction $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$
(1) $K_p = K_c$ (2) $K_p = K_c(RT)^{-1}$
(3) $K_p = K_c(RT)$ (4) $K_p = K_c(RT)^2$

Q.27 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
(1) K_p is greater than K_c
(2) K_p is less than K_c
(3) $K_p = K_e$
(4) Whether K_p is greater than, less than or equal to K_c depends upon the total gas pressure

Q.28 The reaction between N_2 and H_2 to form ammonia has $K_c = 6 \times 10^{-2}$ at the temperature $500°C$. The numerical value of K_p for this reaction is
(1) 1.5×10^{-5} (2) 1.5×10^{5}
(3) 1.5×10^{-6} (4) 1.5×10^{6}

Reaction quotient and its applications

Q.29 In which of the following, the reaction proceeds towards completion

(1) $K = 10^3$ (2) $K = 10^{-2}$

(3) $K = 10$ (4) $K = 1$

Properties of equilibrium constant

Q.30 The equilibrium constant of the reaction $H_2(g) + I_2(g)$ $\rightleftharpoons 2HI(g)$ is 64. If the volume of the container is reduced to one fourth of its original volume, the value of the equilibrium constant will be

(1) 16   (2) 32   (3) 64   (4) 128

Q.31 A reversible chemical reaction having two reactants in equilibrium. If the concentrations of the reactants are doubled, then the equilibrium constant will

(1) Also be doubled   (2) Be halved

(3) Become one-fourth   (4) Remain the same

Q.32 Two gaseous equilibria $SO_{2(g)} + \frac{1}{2}O_{2(g)} \rightleftharpoons SO_{3(g)}$ and $2SO_{3(g)} \rightleftharpoons 2SO_{2(g)} + O_{2(g)}$ have equilibrium constants K_1 and K_2 respectively at $298\,K$. Which of the following relationships between K_1 and K_2 is correct

(1) $K_1 = K_2$ (2) $K_2 = K_1^2$

(3) $K_2 = \dfrac{1}{K_1^2}$ (4) $K_2 = \dfrac{1}{K_1}$

Q.33 Equilibrium constant for the synthesis of HI is 50. K for dissociation of HI is

(1) 50   (2) 5   (3) 0.2   (4) 0.02

Q.34 The equilibrium constant for the reversible reaction, $N_2 + 3H_2 \rightleftharpoons 2NH_3$ is K and for the reaction $\frac{1}{2}N_2 + \frac{3}{2}H_2 \rightleftharpoons NH_3$ the equilibrium constant is K'. K and K' will be related as

(1) $K = K'$ (2) $K' = \sqrt{K}$ (3) $K = \sqrt{K'}$ (4) $K \times K' = 1$

Q.35 $2NO_2 \rightleftharpoons 2NO + O_2;\ K = 1.6 \times 10^{-12}$

$NO + \frac{1}{2}O_2 \rightleftharpoons NO_2\ K' = ?$

(1) $K' = \dfrac{1}{K^2}$ (2) $K' = \dfrac{1}{K}$

(3) $K' = \dfrac{1}{\sqrt{K}}$ (4) None of these

Q.36 The equilibrium constant for the reaction $N_2 + 3H_2 \rightleftharpoons 2NH_3$ is K, then the equilibrium constant for the equilibrium $NH_3 \rightleftharpoons \frac{1}{2}N_2 + \frac{3}{2}H_2$ is

(1) $1/K$ (2) $1/K^2$ (3) $\sqrt{K}$ (4) $\dfrac{1}{\sqrt{K}}$

**Q.37** For the gaseous phase reaction

$2NO \rightleftharpoons N_2 + O_2 \quad \Delta H° = +43.5\ kcal\ mol^{-1}$

Which statement is correct

(1) K varies with addition of NO

(2) K decrease as temperature decreases

(3) K Increases as temperature decreases

(4) K is independent of temperature

Q.38 If K_c is the equilibrium constant for the formation of NH_3, the dissociation constant of ammonia under the same temperature will be

(1) K_c (2) $\sqrt{K_c}$ (3) K_c^2 (4) $1/K_c$

Q.39 If for $H_{2(g)} + \frac{1}{2}S_{2(S)} \rightleftharpoons H_2S_{(g)}$ and

$H_{2(g)} + Br_{2(g)} \rightleftharpoons 2HBr_{(g)}$
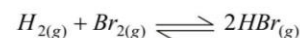
The equilibrium constants are K_1 and K_2 respectively, the reaction $Br_{2(g)} + H_2S_{(g)} \rightleftharpoons 2HBr_{(g)} + \frac{1}{2}S_{2(S)}$ would have equilibrium constant

(1) $K_1 \times K_2$ (2) K_1/K_2 (3) K_2/K_1 (4) K_2^2/K_1

Degree of dissociation (1) and vapour density

Q.40 5 moles of SO_2 and 5 moles of O_2 are allowed to react to form SO_3 in a closed vessel. At the equilibrium stage 60% of SO_2 is used up. The total number of moles of SO_2, O_2 and SO_3 in the vessel now is

(1) 10.0   (2) 8.5   (3) 10.5   (4) 3.9

Q.41 9.2 *grams* of $N_2O_{4(g)}$ is taken in a closed one litre vessel and heated till the following equilibrium is reached $N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$. At equilibrium, 50% $N_2O_{4(g)}$ is dissociated. What is the equilibrium constant (in *mol litre*$^{-1}$) (Molecular weight of $N_2O_4 = 92$)

(1) 0.1   (2) 0.4   (3) 0.2   (4) 2

Q.42 3.2 moles of hydrogen iodide were heated in a sealed bulb at $444°C$ till the equilibrium state was reached. Its degree of dissociation at this temperature was found to be 22%. The number of moles of hydrogen iodide present at equilibrium are

(1) 2.496   (2) 1.87   (3) 2   (4) 4

Q.43 What is the effect of increasing pressure on the dissociation of PCl_5 according to the equation

$$PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)} - x \ cal$$
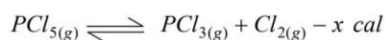
(1) Dissociation decreases
(2) Dissociation increases
(3) Dissociation does not change
(4) None of these

Q.44 The vapour density of completely dissociated NH_4Cl would be

(1) Slight less than half that of NH_4Cl

(2) Half that of NH_4Cl

(3) Double that of NH_4Cl

(4) Determined by the amount of solid NH_4Cl in the experiment

Q.45 If dissociation for reaction, $PCl_5 \rightleftharpoons PCl_3 + Cl_2$ is 20% at 1 atm. pressure. Calculate K_p
(1) 0.04   (2) 0.05   (3) 0.07   (4) 0.06

Heterogeneous Equilibrium

Q.46 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
(1) 0.30   (2) 0.18   (3) 0.17   (4) 0.11

Q.47 Some solid NH_4HS is placed in a flask containing 0.5 atm of NH_3, what would be pressures of NH_3 when equilibrium is reached

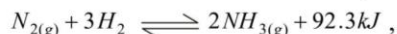$$NH_4HS_{(g)} \rightleftharpoons NH_{3(g)} + H_2S_{(g)},$$

$K_p = 0.11$

(1) 6.65 atm   (2) 0.665 atm
(3) 0.0665 atm   (4) 66.5 atm

Le-chatelier's principle

Q.48 In the manufacture of ammonia by Haber's process,

$$N_{2(g)} + 3H_2 \rightleftharpoons 2NH_{3(g)} + 92.3 kJ,$$

which of the following conditions is unfavourable
(1) Increasing the temperature
(2) Increasing the pressure
(3) Reducing the temperature
(4) Removing ammonia as it is formed

Q.49 For the reaction $PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$ the position of equilibrium can be shifted to the right by
(1) Increasing the temperature
(2) Doubling the volume
(3) Addition of Cl_2 at constant volume
(4) Addition of equimolar quantities of PCl_3 and PCl_5

Q.50 What is the effect of halving the pressure by doubling the volume on the following system at $500°C$

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$
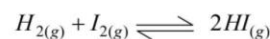
(1) Shift to product side
(2) Shift to product formation
(3) Liquefaction of HI
(4) No effect

Q.51 In equilibrium

$$CH_3COOH + H_2O \rightleftharpoons CH_3COO + H_3^+O$$
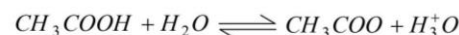
The equilibrium constant may change when
(1) CH_3COO^- are added
(2) CH_3COOH is added
(3) Catalyst is added
(4) Mixture is heated

Q.52 In the reaction, $A_2(g) + 4B_2(g) \rightleftharpoons 2AB_4(g)$,

$\Delta H < 0$ the formation of AB_4 is will be favoured at
(1) Low temperature, high pressure
(2) High temperature, low pressure
(3) Low temperature, low pressure
(4) High temperature, high pressure

Q.53 For the reaction $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$, the equilibrium constant changes with
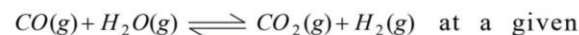(1) Total pressure
(2) Catalyst
(3) The amounts of H_2 and I_2 taken
(4) Temperature

Q.54 $N_2 + O_2 \rightleftharpoons 2NO - Q \ cals$
In the above reaction which is the essential condition for the higher production of NO
(1) High temperature   (2) High pressure
(3) Low temperature   (4) Low pressure

Q.55 For the reaction
$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$ at a given temperature, the equilibrium amount of $CO_2(g)$ can be increased by
(1) Adding a suitable catalyst
(2) Adding an inert gas
(3) Decreasing the volume of the container
(4) Increasing the amount $CO(g)$

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Q.56 Which of the following reactions proceed at low pressure

(1) $N_2 + 3H_2 \rightleftharpoons 2NH_3$

(2) $H_2 + I_2 \rightleftharpoons 2HI$

(3) $PCl_5 \rightleftharpoons PCl_3 + Cl_2$

(4) $N_2 + O_2 \rightleftharpoons 2NO$

Thermodynamic of equilibrium and miscellaneous

Q.57 For a system in equilibrium $\Delta G = 0$ under conditions of constant
(1) Temperature and pressure
(2) Temperature and volume
(3) Energy and volume
(4) Pressure and volume

Q.58 A reaction attains equilibrium when the free energy change accompanying it is
(1) Positive and large   (2) Zero
(3) Negative and large   (4) Negative and small

IONIC EQUILIBRIUM

Acid Base Concept

Q.59 Review the equilibrium and choose the correct statement $HClO_4 + H_2O \rightleftharpoons H_3O^+ + ClO_4^-$

(1) $HClO_4$ is the conjugate acid of H_2O

(2) H_3O^+ is the conjugate base of H_2O

(3) H_2O is the conjugate acid of H_3O^+

(4) ClO_4^- is the conjugate base of $HClO_4$

Q.60 Which of the following can act both as Bronsted acid and Bronsted base

(1) Cl^- (2) HCO_3^- (3) H_3O^+ (4) OH^-

Q.61 An example of a Lewis acid is
(1) $NaCl$ (2) $MgCl_2$ (3) $AlCl_3$ (4) $SnCl_4$

Q.62 With reference to protonic acids, which of the following statements is correct
(1) PH_3 is more basic than NH_3
(2) PH_3 is less basic than NH_3
(3) PH_3 is equally basic as NH_3
(4) PH_3 is amphoteric while NH_3 is basic

Q.63 Dissociation of H_3PO_4 takes place in following steps
(1) 1   (2) 2
(3) 3   (4) 4

Q.64 The correct order of acid strength is
(1) $HClO < HClO_2 < HClO_3 < HClO_4$
(2) $HClO_4 < HClO < HClO_2 < HClO_3$
(3) $HClO_2 < HClO_3 < HClO_4 < HClO$
(4) $HClO_4 < HClO_3 < HClO_2 < HClO$

Q.65 Water is a
(1) Amphoteric acid   (2) Aprotic solvent
(3) Protophobic solvent (4) None of these

Q.66 According to Bronsted principle, an aqueous solution of HNO_3 will contain
(1) NO_2^- (2) NO_3^- (3) NO_2^+ (4) NO^+

Q.67 The species which acts as a Lewis acid but not a Bronsted acid is
(1) NH_2^- (2) O^{2-} (3) BF_3 (4) OH^-

Properties of water, pH scale, Autoprotolysis

Q.68 The unit of ionic product of water K_w are
(1) $Mol^{-1}L^{-1}$ (2) $Mol^{-2}L^{-2}$
(3) $Mol^{-2}L^{-1}$ (4) Mol^2L^{-2}

Q.69 At $90^o C$ pure water has $[H_3O^+] = 10^{-6} M$, the value of K_w at this temperature will be
(1) 10^{-6} (2) 10^{-12} (3) 10^{-14} (4) 10^{-8}

Q.70 The pH of $1 N H_2O$ is
(1) 7   (2) > 7   (3) < 7   (4) 0

Relation between Ka and Kb for conjugate acid - base pair, Levelling/Differentiating effect of solvent

Q.71 In the equilibrium :

$$CH_3COOH + HF \rightleftharpoons CH_3COOH_2^+ + F^-$$

(1) F^- is the conjugate acid of CH_3COOH
(2) F^- is the conjugate base of HF
(3) CH_3COOH is the conjugate acid of $CH_3COOH_2^+$
(4) $CH_3COOH_2^+$ is the conjugate base of CH_3COOH

Q.72 Which of the following is a conjugated acid-base pair
(1) $HCl, NaOH$

(2) NH_4Cl, NH_4OH

(3) H_2SO_4, HSO_4^-

(4) KCN, HCN

Q.73 The conjugate acid of HPO_3^{2-} is

(1) H_3PO_4 (2) H_3PO_3 (3) $H_2PO_3^-$ (4) PO_4^{3-}

Q.74 The conjugate acid of NH_2^- is

(1) NH_3 (2) NH_4^+

(3) NH_2OH (4) N_2H_4

Q.75 Among the following, the weakest base is

(1) H^- (2) CH_3^- (3) CH_3O^- (4) Cl^-

pH calculation : Strong acid solutions, Strong base solutions, Solutions containing mixture of two or more strong acids, Solutions containing mixture of two or more strong bases, Solutions containing mixture of strong acid and strong base, mixture of S.A. and W.A. S.B. and W.B.

Q.76 Aqueous solution of HCl has the $pH = 4$. Its molarity would be

(1) 4 M   (2) 0.4 M

(3) 0.0001 M   (4) 10 M

Q.77 What is the pH value of $\dfrac{N}{1000} KOH$ solution

(1) 10^{-11} (2) 3   (3) 2   (4) 11

Q.78 $pH + pOH$ equal to (at 25°C)

(1) Zero   (2) Fourteen

(3) A negative number   (4) Infinity

Q.79 Which one has pH 12

(1) 0.01 M KOH (2) 1 N KOH ml

(3) 1 N $NaOH$ ml   (4) 1 N $Ca(OH)_2$ ml

Q.80 pH values of HCl and $NaOH$ solutions each of strength $\dfrac{N}{100}$ will be respectively

(1) 2 and 2   (2) 2 and 12

(3) 12 and 2   (4) 2 and 10

Q.81 What will be the pH of a $10^{-8} M HCl$ solution

(1) 8.0   (2) 7.0   (3) 6.98   (4) 14.0

Q.82 pH of completely dissociated $0.005 M H_2SO_4$ is

(1) 3   (2) 4   (3) 2   (4) 5

Q.83 The pH of a 0.02 M solution of hydrochloric acid is

(1) 2.0   (2) 1.7   (3) 0.3   (4) 2.2

Q.84 $NaOH_{(aq)}, HCl_{(aq)}$ and $NaCl_{(aq)}$ concentration of each is $10^{-3} M$. Their pH will be respectively

(1) 10, 6, 2 (2) 11, 3, 7 (3) 10, 2, 6 (4) 3, 4, 7

Q.85 The pH of a 10^{-10} molar HCl solution is approximately

(1) 10   (2) 7   (3) 1   (4) 14

Ostwald dilution law, pH calculation : Solutions of weak monoprotic acid, Solutions of weak monoacidic base

Q.86 Electrolytes when dissolved in water dissociate into their constituent ions. The degree of dissociation of an electrolyte increases with
(1) Increasing concentration of the electrolyte
(2) Decreasing concentration of the electrolyte
(3) Decreasing temperature
(4) Presence of a substance yielding a common ion

Q.87 An electrolyte
(1) Gives complex ions in solution
(2) Dissociates in water to give ions
(3) Is ionized in the solid state
(4) Generates ions on passing electric current

Q.88 A monoprotic acid in 1.00 M solution is 0.01% ionised. The dissociation constant of this acid is

(1) 1×10^{-8} (2) 1×10^{-4} (3) 1×10^{-6} (4) 10^{-5}

Q.89 Which one is strongest electrolyte in the following

(1) $NaCl$ (2) CH_3COOH

(3) NH_4OH (4) $C_6H_{12}O_6$

Q.90 If α is the degree of ionization, C is the concentration of a weak electrolyte and K_a is the acid ionization constant, then the correct relationship between α, C and K_a is

(1) $\alpha^2 = \sqrt{\dfrac{K_a}{C}}$ (2) $\alpha^2 = \sqrt{\dfrac{C}{K_a}}$

(3) $\alpha = \sqrt{\dfrac{K_a}{C}}$ (4) $\alpha = \sqrt{\dfrac{C}{K_a}}$

Q.91 The extent of ionization increases
(1) With the increase in concentration of solute
(2) On addition of excess water to solution
(3) On decreasing the temperature of solution
(4) On stirring the solution vigorously

Q.92 For a weak acid HA, Ostwald's dilution law is represented by the equation

(1) $K_a = \dfrac{\alpha c}{1 - \alpha^2}$ (2) $K_a = \dfrac{\alpha^2 c}{1 - \alpha}$

(3) $\alpha = \dfrac{K_a c}{1 - c}$ (4) $K_a = \dfrac{\alpha^2 c}{1 - \alpha^2}$

Q.93 Concentration CN^- in $0.1\,M\,HCN$ is $[K_a = 4 \times 10^{-10}]$

(1) $2.5 \times 10^{-6}\,M$ (2) $4.5 \times 10^{-6}\,M$

(3) $6.3 \times 10^{-6}\,M$ (4) $9.2 \times 10^{-6}\,M$

Q.94 0.02 M monobasic acid dissociates 2% hence, pH of the solution is
(1) 0.3979 (2) 1.3979 (3) 1.699 (4) 3.3979

Q.95 The pH of 0.1 M acetic acid is 3, the dissociation constant of acid will be

(1) 1.0×10^{-4} (2) 1.0×10^{-5}

(3) 1.0×10^{-3} (4) 1.0×10^{-8}

Q.96 The pH value of decinormal solution of NH_4OH which is 20% ionised, is
(1) 13.30 (2) 14.70 (3) 12.30 (4) 12.95

Salt hydrolysis, pH calculation : Solutions of salt of monoprotic acid and monoacidic base, common ion effect.

Q.97 Aqueous solution of sodium acetate is
(1) Neutral   (2) Weakly acidic
(3) Strongly acidic   (4) Alkaline

Q.98 Which is the correct alternate for hydrolysis constant of NH_4CN

(1) $\sqrt{\dfrac{K_w}{K_a}}$ (2) $\dfrac{K_w}{K_a \times K_b}$ (3) $\sqrt{\dfrac{K_b}{c}}$ (4) $\dfrac{K_a}{K_b}$

Q.99 An aqueous solution of CH_3COONa will be
(1) Acidic   (2) Alkaline
(3) Neutral   (4) None of these

Q.100 In which of the following salt hydrolysis takes place
(1) KCl (2) $NaNO_3$
(3) CH_3COOK (4) K_2SO_4

Q.101 Which of the following aqueous solution will have a pH less than 7.0
(1) KNO_3 (2) $NaOH$ (3) $FeCl_3$ (4) $NaCN$

Q.102 Hydrolysis constant for a salt of weak acid and weak base would be

(1) $K_h = \dfrac{K_w}{K_a}$ (2) $K_h = \dfrac{K_w}{K_b}$

(3) $K_h = \dfrac{K_w}{K_a K_b}$ (4) None of these

Q.103 The pH of a $0.001\,M\,NaOH$ will be
(1) 3   (2) 2   (3) 11   (4) 12

Q.104 When 10 ml of 0.1 M acetic acid ($pK_a = 5.0$) is titrated against 10 ml of 0.1M ammonia solution ($pK_b = 5.0$), the equivalence point occurs at pH
(1) 5.0   (2) 6.0   (3) 7.0   (4) 9.0

Q.105 A solution of $MgCl_2$ in water has pH
(1) < 7   (2) > 7   (3) 7   (4) 14.2

Q.106 Which of the following salt is acidic
(1) Na_2SO_4 (2) $NaHSO_3$
(3) Na_2SO_3 (4) Na_2S

Buffer solution
Q.107 An acidic buffer solution can be prepared by mixing solution of
(1) Ammonium acetate and acetic acid
(2) Ammonium chloride and hydrochloric acid
(3) Sulphuric acid and sodium sulphate
(4) Acetic acid and sulphuric acid

Q.108 The pH of a simple sodium acetate buffer is given by

$$pH = pK_a + \log \dfrac{[Salt]}{[Acid]}$$ K_a of acetic acid $= 1.8 \times 10^{-5}$

If $[Salt] = [Acid] = 0.1$ M, the pH of the solution would be about
(1) 7   (2) 4.7   (3) 5.3   (4) 1.4

Q.109 Which of the following solutions can act as buffer
(1) 0.1 molar aq. NaCl
(2) 0.1 molar aq. CH_3COOH + 0.1 molar NaOH
(3) 0.1 molar aq. ammonium acetate
(4) None of the above

Q.110 Which of the following solutions cannot act as a buffer
(1) $NaH_2PO_4 + H_3PO_4$
(2) $CH_3COOH + CH_3COONa$
(3) $HCl + NH_4Cl$
(4) $H_3PO_4 + Na_2HPO_4$

Q.111 One weak acid (like CH_3COOH) and its strong base together with salt (like CH_3COONa) is a buffer solution. In which pair this type of characteristic is found
(1) HCl and $NaCl$ (2) $NaOH$ and $NaNO_3$
(3) KOH and KCl (4) NH_4OH and NH_4Cl

Q.112 50 ml of 2 N acetic acid ($K_a = 1.8 \times 10^{-5}$) mixed with 10 ml of 1 N sodium acetate solution will have an approximate pH of
(1) 4 (2) 5 (3) 6 (4) 7

Solubility and titration

Q.113 The solubility product of $BaSO_4$ at $25°C$ is 1.0×10^{-9}. What would be the concentration of H_2SO_4 necessary to precipitate $BaSO_4$ from a solution of 0.01 M Ba^{2+} ions

(1) 10^{-9} (2) 10^{-8} (3) 10^{-7} (4) 10^{-6}

Q.114 The solubility of CaF_2 is a moles/litre. Then its solubility product is .....
(1) s^2 (2) $4s^3$ (3) $3s^2$ (4) s^3

Q.115 The solubility of CaF_2 is 2×10^{-4} moles / litre. Its solubility product (K_{sp}) is
(1) 2.0×10^{-4} (2) 4.0×10^{-3}
(3) 8.0×10^{-12} (4) 3.2×10^{-11}

EXERCISE-II

Q.1 The reaction $A(g) + B(g) \rightleftharpoons C(g) + D(g)$ is studied in a one litre vessel at 250°C. The initial concentration of A was 3n and that of B was n. When equilibrium was attained, equilibrium concentration of C was found to the equal to the equilibrium concentration of B. What is the concentration of D at equilibrium?
(1) n/2 (2) (3n – 1/2)
(3) (n – n/3) (4) n

Q.2 A 20.0 litre vessel initially contains 0.50 mole each of H_2 and I_2 gases. These substances react and finally reach an equilibrium condition. Calculate the equilibrium concentration of HI if K_{eq} = 49 for the reaction
$H_2 + I_2 \rightleftharpoons 2HI$.
(1) 0.78 M (2) 0.039 M (3) 0.033 M (4) 0.021 M

Q.3 A chemical reaction $A \rightleftharpoons B$ is said to be in equilibrium when -
(1) Complete conversion of A to B has taken place
(2) Conversion of A to B is only 50% complete
(3) Only 10% conversion of A to B has taken place
(4) The rate of transformation of A to B is just equal to rate of transformation of B to A in the system

Q.4 According to Law of Mass action, the rate of reaction is directly proportional to -
(1) molarities of the reactants
(2) normalities of the reactants
(3) molalities of the reactants
(4) mole fractions of the reactants

Q.5 In a chemical equilibrium, the equilibrium constant is found to be 2.5. If the rate constant of backward

reaction is 3.2×10^{-2}, the rate constant of forward reaction is -
(1) 8.0×10^{-2} (2) 4.0×10^{-2}
(3) 3.5×10^{-2} (4) 7.6×10^{-3}

Homogeneous equilibrium : K_C

Q.6 When alcohol (C_2H_5OH (ℓ)) and acetic acid (CH_3COOH (ℓ)) are mixed together in equimolar ratio at 27°C, 33% of each is converted into ester. Then the K_C for the equilibrium
$C_2H_5OH(\ell) + CH_3COOH (\ell)$
$\rightleftharpoons CH_3COOC_2H_5 (\ell) + H_2O(\ell)$.
(1) 4 (2) 1/4 (3) 9 (4) 1/9
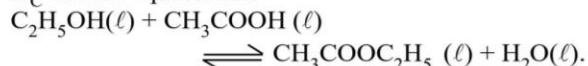
Q.7 For the reaction equilibrium :
$N_2O_4 (g) \rightleftharpoons 2NO_2(g)$; the concentration of N_2O_4 and NO_2 at equilibrium are 4.8×10^{-2} and 1.2×10^{-2} mol/L respectively. The value of K_c for the reaction is :
(1) 3×10^{-3} M (2) 3×10^3 M
(3) 3.3×10^2 M (4) 3×10^{-1} M
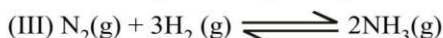
Q.8 The equilibrium constant for the reaction :
$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ at temperature T is 4×10^{-4}. The value of K_c for the reaction.
$NO(g) \rightleftharpoons \dfrac{1}{2} N_2(g) + \dfrac{1}{2} O_2(g)$ at the same temperature is :
(1) 0.02 (2) 50 (3) 4×10^{-4} (4) 2.5×10^{-2}
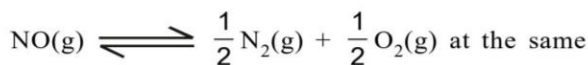
Q.9 Consider following reactions in equilbrium with equilibrium concentration 0.01M of every species
(I) $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

(II) $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$

(III) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

Extent of the reactions taking place is :

(1) I > II > III   (2) I < II < III

(3) II < III < I   (4) III < I < II

Q.10 The equilibrium constant for the reaction $A(g) + 2B(g) \rightleftharpoons C(g)$ is $0.25 \ dm^6 \ mol^{-2}$. In a volume of 5 dm^3, what amount of A must be mixed with 4 mol of B to yield 1 mol of C at equilibrium.

(1) 3 moles   (2) 24 moles

(3) 26 moles   (4) None of these

Q.11 1 mole N_2 and 3 mol H_2 are placed in a closed container at a pressure of 4 atm. The pressure falls to 3 atm at the same temperature when the following equilibrim is attained. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$. The equilibrium constant K_p for dissociation of NH_3 is :

(1) $\dfrac{1}{0.5} \times (1.5)^3 \ atm^{-2}$ (2) $0.5 \times (1.5)^3 \ atm^2$

(3) $\dfrac{0.5 \times (1.5)^3}{3 \times 3} \ atm^2$ (4) $\dfrac{3 \times 3}{0.5 \times (1.5)^3} \ atm^{-2}$

Q.12 The value of K_p for the reaction, $2H_2O(g) + 2Cl_2(g) \rightleftharpoons 4HCl(g) + O_2(g)$ is 0.03 atm at 427° C, when the partial pressure are expressed in atmosphere then the value of K_C for the same reaction is

(1) 5.23×10^{-4} (2) 7.34×10^{-4}

(3) 3.2×10^{-3} (4) 5.43×10^{-5}

Q.13 $\log \dfrac{K_p}{K_c} + \log RT = 0$ is a relationship for the reaction :

(1) $PCl_5 \rightleftharpoons PCl_3 + Cl_2$

(2) $2SO_2 + O_2 \rightleftharpoons 2SO_3$

(3) $H_2 + I_2 \rightleftharpoons 2HI$

(4) $N_2 + 3H_2 \rightleftharpoons 2NH_3$

Q.14 For the following gases equilibrium.

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$ K_p is found to be equal to K_c. This is attained when temperature is

(1) 0°C   (2) 273 K   (3) 1 K   (4) 12.19 K

Q.15 For the reaction :

$CO(g) + \dfrac{1}{2}O_2(g) \rightleftharpoons CO_2(g)$, K_p/K_c is :

(1) RT   (2) $(RT)^{-1}$ (3) $(RT)^{-1/2}$ (4) $(RT)^{1/2}$

Q.16 At 675 K, $H_2(g)$ and $CO_2(g)$ react to form $CO(g)$ and $H_2O(g)$, K_p for the reaction is 0.16. If a mixture of 0.25 mole of $H_2(g)$ and 0.25 mol of CO_2 is heated at 675 K, mole% of $CO(g)$ in equilibrium mixture is :

(1) 7.14   (2) 14.28   (3) 28.57   (4) 33.33

Q.17 The value of K_p for the reaction $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ is 50. What is the value of K_C

(1) 30   (2) 40   (3) 50   (4) 70

Q.18 PCl_5 dissociation a closed container as :

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

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

(1) $P \cdot \left[\dfrac{\alpha}{\alpha+1}\right]$ (2) $P \cdot \left[\dfrac{2\alpha}{1-\alpha}\right]$

(3) $P \cdot \left[\dfrac{\alpha}{\alpha-1}\right]$ (4) $P \cdot \left[\dfrac{\alpha}{1-\alpha}\right]$

Q.19 In the dissociation of N_2O_4 into NO_2, $(1 + \alpha)$ values with the vapour densities ratio $\left(\dfrac{D}{d}\right)$ is as given by:

[α-degree of dissociation, D-vapour density before dissociation, d-vapour density after dissociation]
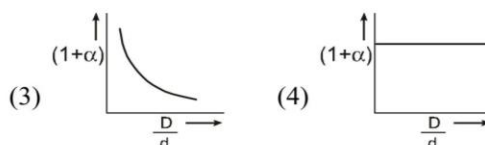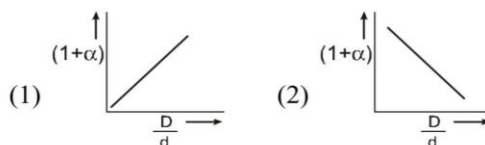
Q.20 In the dissociation of N_2O_4 into NO_2, α values with the vapour densities ratio $\left(\dfrac{D}{d}\right)$ is as given by: [α-degree of dissociation, D-vapour density before dissociation, d-vapour density after dissociation]
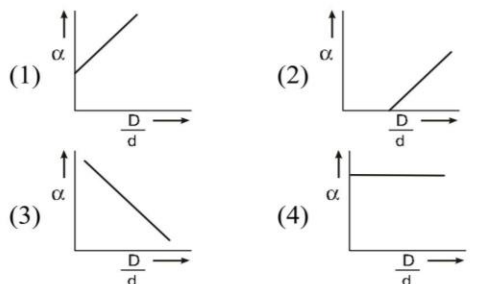
Q.21 For the reaction : $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$, the degree of dissociation α of $HI(g)$ is related to equilibrium constant K_p by the expression :

(1) $\dfrac{1+2\sqrt{K_p}}{2}$

(2) $\sqrt{\dfrac{1+2K_p}{2}}$

(3) $\sqrt{\dfrac{2K_p}{1+2K_p}}$

(4) $\dfrac{2\sqrt{K_p}}{1+2\sqrt{K_p}}$

Q.22 For the reaction $N_2O_4(g) \rightleftharpoons 2NO_2(g)$, if percentage dissociation of N_2O_4 are 20%, 45%, 65% & 80%, then the sequence of observed vapour densities will be :

(1) $d_{20} > d_{45} > d_{65} > d_{80}$
(2) $d_{80} > d_{65} > d_{45} > d_{20}$
(3) $d_{20} = d_{45} = d_{65} = d_{80}$
(4) $(d_{20} = d_{45}) > (d_{65} = d_{80})$

Q.23 The vapour density of N_2O_4 at a certain temperature is 30. What is the % dissociation of N_2O_4 at this temperature ?
(1) 53.3 %   (2) 106.6 % (3) 26.7 %   (4) None

Q.24 For the reaction
$$A_{(g)} + B_{(g)} \rightleftharpoons C_{(g)} + D_{(g)},$$
the degree of dissociation α would be –

(1) $\dfrac{\sqrt{K}}{\sqrt{K}+1}$ (2) $\sqrt{K}+1$ (3) $\sqrt{K} \pm 1$ (4) $\sqrt{K}-1$

Q.25 An unknown compound A dissociates at 500ºC to give products as follows -
$$A(g) \rightleftharpoons B(g) + C(g) + D(g)$$
Vapour density of the equilibrium mixture is 50 when it dissociates to the extent to 10%. What will be the molecular weight of Compound A –
(1) 120   (2) 130
(3) 134   (4) 140
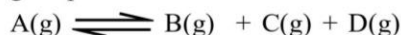
Q.26 N_2O_4 dissociates as
$N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$ at 273 K and 2 atm pressure. The equilibrium mixture has a density of 41. What will be the degree of dissociation -
(1) 14.2%   (2) 16.2%
(3) 12.2%   (4) None

Q.27 The equation $\alpha = \dfrac{D-d}{(n-1)d}$ is correctly matched for :

(1) $A(g) \rightleftharpoons (n/2)B(g) + (n/3)C(g)$
(2) $A(g) \rightleftharpoons (n/3)B(g) + (2n/3)C(g)$
(3) $A(g) \rightleftharpoons (n/2)B(g) + (n/4)C(g)$
(4) $A(g) \rightleftharpoons (n/2)B(g) + C(g)$

Q.28 For the reaction $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$
$K_c = 66.9$ at 350°C and $K_c = 50.0$ at 448°C. The reaction has
(1) $\Delta H = +$ ve
(2) $\Delta H = -$ ve
(3) $\Delta H =$ zero
(4) ΔH sign can not be determined

Q.29 Variation of $\log_{10} K$ with $\dfrac{1}{T}$ is shown by the following graph in which straight line is at 45°, hence $\Delta H°$ is:
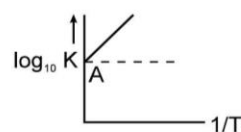
(1) + 4.606 cal   (2) – 4.606 cal
(3) 2 cal   (4) – 2cal

Q.30 Change in volume of the system does not alter the number of moles in which of the following equilibrium

(1) $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$
(2) $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$
(3) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
(4) $SO_2Cl_2(g) \rightleftharpoons SO_2(g) + Cl_2(g)$

Q.31 The conditions favourable for the reaction :
$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$; $\Delta H° = -198$ kJ
are :
(1) low temperature, high pressure
(2) any value of T and P
(3) low temperature and low pressure
(4) high temperature and high pressure

Q.32 For the reaction $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$ at a given temperature the equilibrium amount of CO_2 (g) can be increased by :
(1) adding a suitable catalyst
(2) adding an inert gas
(3) decreasing the volume of container
(4) increasing the amount of $CO(g)$

Q.33 Given the following reaction at equilibrium
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$. Some inert gas at constant pressure is added to the system. Predict which of the following facts will be affected.
(1) More $NH_3(g)$ is produced
(2) Less $NH_3(g)$ is produced
(3) No affect on the equilibrium
(4) K_p of the reaction is decreased

Q.34 For an equilibrium $H_2O(s) \rightleftharpoons H_2O(\ell)$ which of the following statements is true.
(1) The pressure changes do not affect the equilibrium
(2) More of ice melts if pressure on the system is increased
(3) More of liquid freezes if pressure on the system is increased
(4) The pressure changes may increase or decrease the degree of advancement of the reaction depending upon the temperature of the system

Q.35 When a bottle of cold drink is opened, the gas comes out with a fizz due to :
(1) Decrease in temperature
(2) Increase in pressure
(3) Decrease in pressure suddenly which results in decrease of solubility of CO_2 gas in water
(4) None

Q.36 The equilibrium $SO_2Cl_2(g) \rightleftharpoons SO_2(g) + Cl_2(g)$ is attained at 25°C in a closed rigid container and an inert gas, helium in introduced. Which of the following statements is/are correct.
(1) concentrations of SO_2, Cl_2 and SO_2Cl_2 do not change
(2) more chlorine is formed
(3) concentration of SO_2 is reduced
(4) more SO_2Cl_2 is formed

Q.37 The yield of product in the reaction :
$$2A(g) + B(g) \rightleftharpoons 2C(g) + Q \text{ kJ}$$
would be lower at :
(1) low temperature and low pressure
(2) high temperature & high pressure
(3) low temperature and high pressure
(4) high temperature & low pressure

Q.38 What is the effect of the reduction of the volume of the system for the equilibrium
$$2C(s) + O_2(g) \rightleftharpoons 2CO(g) ?$$
(1) The equilibrium will be shifted to the left by the increased pressure caused by the reduction in volume
(2) The equilibrium will be shifted to the right by the decreased pressure caused by the reduction in volume.
(3) The equilibrium will be shifted to the left by the increased pressure caused by the increase in volume.
(4) The equilibrium will be shifted to the right by the increased pressure caused by the reduction in volume.

Q.39 An exothermic reaction is represented by the graph :

Q.40
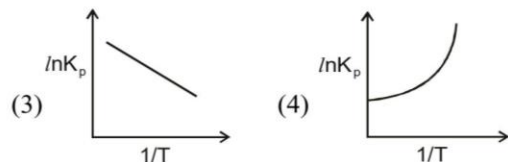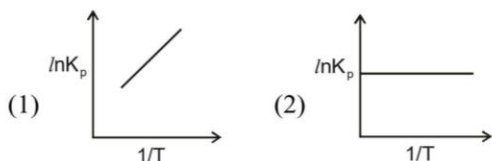
IONIC EQUILIBRIUM

Q.40 The conjugate acid of NH_2^- is
(1) NH_3 (2) NH_2OH (3) NH_4^+ (4) N_2H_4

Q.41 Out of the following, amphiprotic species are
I : HPO_3^{2-} II OH^- III $H_2PO_4^-$ IV HCO_3^-
(1) I, III, IV   (2) I and III
(3) III and IV   (4) All

Q.42 Which of the following expression is not true ?
(1) $[H^+] = [OH^-] =$ for a neutral solution at all temperatures.
(2) $[H^+] > \& [OH^-] <$ for an acidic solution
(3) $[H^+] < \& [OH^-] >$ for an alkaline solution
(4) $[H^+] = [OH^-] = 10^{-7}$ M for a neutral solution at all temperatures .

Q.43 pOH of H_2O is 7.0 at 298 K . If water is heated at 350 K, which of the following statement should be true?
(1) pOH will decrease.
(2) pOH will increase.
(3) pOH will remain 7.0.
(4) concentration of H^+ ions will increase but that of OH^- will decrease.

Q.44 Which statement/relationship is correct?
(1) pH of 0.1 M HNO_3, 0.1M HCl, 0.1M HI are not equal.
(2) pH $= - \log [H^+]$
(3) The pH of pure water is 7.
(4) The value of pK_w at 25 °C is 7.

Q.45 One litre of solution contains 10^{-5} moles of OH^- ions at 25°C. Percentage ionisation of water in solution is :
(1) 1.8×10^{-7} %   (2) 1.8×10^{-9} %
(3) 3.6×10^{-9} %   (4) 1.8×10^{-11} %.

Q.46 A solution with pH 2.0 is more acidic than the one with pH 6.0 by a factor of :
(1) 3   (2) 4   (3) 3000   (4) 10,000

Q.47 The $[OH^-]$ in 100.0 ml of 0.016 M-HCl (aq) is :
(1) 5×10^{12} M   (2) 3×10^{-10} M
(3) 6.25×10^{-13} M   (4) 2.0×10^{-9} M.

Q.48 How many moles of NaOH must be removed from one litre of aqueous solution to change its pH from 12 to 11 ?
(1) 0.009   (2) 0.01   (3) 0.02   (4) 0.1

Q.49 Which of the following solution will have pH close to 1.0 ?

(1) 100 ml of M/10 HCl + 100 ml of M/10 NaOH
(2) 55 ml of M/10 HCl + 45 ml of M/10 NaOH
(3) 10 ml of M/10 HCl + 90 ml of M/10 NaOH
(4) 75 ml of M/5 HCl + 25 ml of M/5 NaOH.

Q.50 The dissociation constant of acetic acid at a given temperature is 1.69×10^{-5}. The degree of dissociation of 0.01 M acetic acid in the presence of 0.01 M HCl is equal to
(1) 0.41   (2) 0.13
(3) 1.69×10^{-3} (4) 0.013.

Q.51 The pK_a of a weak acid (HA) is 4.5. The pOH of an aqueous buffered solution of HA in which 50% of the acid is ionized is:
(1) 4.5   (2) 2.5   (3) 9.5   (4) 7.0

Q.52 Find the pH of solution prepared by mixing 25ml of a 0.5 M solution of HCl, 10ml of a 0.5 M solution of NaOH and 15ml of water –
(1) 0.8239   (2) 1.0029   (3) 1.0239   (4) 1.8239

Q.53 Determine degree of dissociation of 0.05 M NH_3 at 25°C in a solution of pH = 11.
(1) 2%   (2) 4%   (3) 5%   (4) 10%

Q.54 Which of the following has the highest degree of ionisation ?
(1) 1 M NH_3 (2) 0.001 M NH_3
(3) 0.1 M NH_3 (4) 0.0001 M NH_3.

Q.55 If pK_b for fluoride ion at 25°C is 10.83, the ionisation constant of hydrofluoric acid in water at this temperature is :
(1) 1.74×10^{-5} (2) 3.52×10^{-3}
(3) 6.75×10^{-4} (4) 5.38×10^{-2}

Q.56 The pH of an aqueous solution of 1.0 M solution of a weak monoprotic acid which is 1% ionised is:
(1) 1   (2) 2   (3) 3   (4) 11

Q.57 Ostwald's dilution law gives satisfactory results for -
(1) HCl   (2) HNO_3
(3) CH_3COOH (4) NaOH

Q.58 pH of an aqueous solution of NaCl at 85°C should be
(1) 7   (2) > 7   (3) < 7   (4) 0

Q.59 1 c.c. of 0.1N HCl is added to 99 CC solution of NaCl. The pH of the resulting solution will be
(1) 7   (2) 3   (3) 4   (4) 1

Q.60 The degree of hydrolysis of a salt of weak acid and weak base in it's 0.1 M solution is found to be 50%. If the molarity of the solution is 0.2 M, the percentage hydrolysis of the salt should be
(1) 100%   (2) 50%   (3) 25%   (4) none of these

Q.61 What is the percentage hydrolysis of NaCN in solution when the dissociation constant for HCN is 1.3×10^{-9} and $K_w = 1.0 \times 10^{-14}$
(1) 2.48   (2) 5.26   (3) 8.2   (4) 9.6

Q.62 Which of the following salts undergoes anionic hydrolysis?
(1) $CuSO_4$ (2) NH_4Cl (3) $AlCl_3$ (4) K_2CO_3.

Q.63 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:
(1) 8.58   (2) 4.79   (3) 7.01   (4) 9.22

Q.64 The pH of 0.1 M solution of the following salts increases in the order :
(1) NaCl < NH_4Cl < NaCN < HCl
(2) HCl < NH_4Cl < NaCl < NaCN
(3) NaCN < NH_4Cl < NaCl < HCl
(4) HCl < NaCl < NaCN < NH_4Cl

Q.65 1 M NaCl and 1 M HCl are present in an aqueous solution. The solution is
(1) not a buffer solution and with pH < 7
(2) not a buffer solution with pH > 7
(3) a buffer solution with pH < 7
(4) a buffer solution with pH > 7

Q.66 If 40 ml of 0.2 M KOH is added to 160 ml of 0.1 M HCOOH [$K_a = 2 \times 10^{-4}$]. The pOH of the resulting solution is
(1) 3.4   (2) 3.7   (3) 7   (4) 10.3

Q.67 The pH of a solution obtained by mixing 100 ml of 0.2 M CH_3COOH with 100 ml of 0.2 M NaOH would be :
(pK_a for CH_3COOH = 4.74)
(1) 4.74   (2) 8.87   (3) 9.10   (4) 8.57

Q.68 What volume of 0.2 M NH_4Cl solution should be added to 100 ml of 0.1 M NH_4OH solution to produce a buffer solution of pH = 8.7 ?
Given : pK_b of NH_4OH = 4.7 ; log 2 = 0.3
(1) 50 ml   (2) 100 ml   (3) 200 ml   (4) none of these

Q.69 A solution is 0.1 M CH_3COOH and 0.1 M CH_3COONa. Which of the following solution will change its pH significantly ?
(1) Addition of water
(2) Addition of small amount of CH_3COONa with out change in volume
(3) Addition of small amount of CH_3COOH with out change in volume
(4) None will change the pH significantly.

Q.70 K_a for HCN is 5×10^{-10} at 25°C. For maintaining a constant pH of 9, the volume of 5 M KCN solution required to be added to 10 ml of 2M HCN solution is (log 2 = 0.3)
(1) 4 ml   (2) 8 ml   (3) 2 ml   (4) 10 ml

Q.71 How many gm of solid NaOH must be added to 100 ml of a buffer solution which is 0.1 M each with respect to Acid HA and salt $Na^+ A^-$ to make the pH of solution

5.5. Given $pK_a(HA) = 5$ (**Use** antilog $(0.5) = 3.16$)
(1) 2.08×10^{-1} (2) 3.05×10^{-3}
(3) 2.01×10^{-2} (4) None of these

Q.72 When 100 ml of 0.4 M CH_3COOH are mixed with 100 ml of 0.2 M NaOH, the $[H_3O^+]$ in the solution is approximately : $[K_a(CH_3COOH) = 1.8 \times 10^{-5}]$
(1) 1.8×10^{-6} M (2) 1.8×10^{-5} M
(3) 9×10^{-6} M (4) 9×10^{-5} M.

Q.73 The solubility of A_2X_3 is y mol dm^{-3}. Its solubility product is
(1) $6y^2$ (2) $64 y^4$ (3) $36 y^5$ (4) $108 y^5$

Q.74 If K_{sp} for $HgSO_4$ is $6.4 \times 10^{-5} M^2$, then solubility of this substance in mole per m^3 is
(1) 8×10^{-3} (2) 6.4×10^{-5} (3) 8×10^{-6} (4) None of these

Q.75 The precipitate of CaF_2 ($K_{sp} = 1.7 \times 10^{-10}$) is obtained when equal volumes of the following are mixed
(1) 10^{-4} M Ca^{3+} + 10^{-4} M F^-
(2) 10^{-2} M Ca^{2+} + 10^{-3} M F^-
(3) 10^{-5} M Ca^{2+} + 10^{-3} M F^-
(4) 10^{-3} M Ca^{2+} + 10^{-5} M F^-

Q.76 The best indicator for the detection of end point in titration of a weak acid and a strong base is :
(1) Methyl orange (3 to 4)
(2) Methyl red (5 to 6)
(3) Bromothymol blue (6 to 7.5)
(4) Phenolphthalein (8 to 9.6).

Q.77 When equal volumes of the following solutions are mixed, precipitation of AgCl ($K_{sp} = 1.8 \times 10^{-10}$) will occur only with:
(1) 10^{-4} M (Ag^+) and 10^{-4} M (Cl^-)
(2) 10^{-5} M (Ag^+) and 10^{-5} M (Cl^-)
(3) 10^{-6} M (Ag^+) and 10^{-6} M (Cl^-)
(4) 10^{-10} M (Ag^+) and 10^{-10} M (Cl^-)

Q.78 50 litre of a solution containing 10^{-5} mole of Ag^+ is mixed with 50 litre of a 2×10^{-7} M HBr solution. $[Ag^+]$ in resultant solution is: [Given : $Ksp(AgBr) = 5 \times 10^{-13}$]
(1) 10^{-5}M (2) 10^{-6}M
(3) 10^{-7}M (4) None of these

Q.79 What fraction of an indicator HIn is in basic form at a pH of 6 if the pK_a of the indicator is 5 ?

(1) $\frac{1}{2}$ (2) $\frac{1}{11}$ (3) $\frac{10}{11}$ (4) $\frac{1}{10}$

Q.80 K_{sp} of MX_4 is S mol/litre then solubility of MX_4 is related by:
(1) $S = [K_{sp}/256]^{1/5}$ (2) $S = [128 K_{sp}]^{1/4}$
(3) $S = [256 K_{sp}]^{1/5}$ (4) $S = [K_{sp}/128]^{1/4}$

Q.81 If the solubility of lithium sodium hexafluorido aluminate, $Li_3Na_3(AlF_6)_2$ is 's' mol lt^{-1}, its solubility product is equal to :
(1) $729 s^8$ (2) $12 s^8$ (3) $3900 s^8$ (4) $2916 s^8$

Q.82 The solubility of CaF_2 ($K_{sp} = 3.4 \times 10^{-11}$) in 0.1 M solution of NaF would be
(1) 3.4×10^{-12} M (2) 3.4×10^{-10} M
(3) 3.4×10^{-9} M (4) 3.4×10^{-13} M.

Q.83 In a saturated solution of Ag_2CO_3, silver ion concentration is 2×10^{-4} M. Its solubility product is
(1) 4×10^{-12} (2) 3.2×10^{-11}
(3) 8×10^{-12} (4) 10^{-12}

Q.84 The solubility of Ag_2CO_3 in water at 25^0C is 1×10^{-4} mole/litre. What is its solubility in 0.01 M Na_2CO_3 solution? Assume no hydrolysis of CO_3^{2-} ion.
(1) 6×10^{-6} mole/litre (2) 4×10^{-5} mole/litre
(3) 10^{-5} mole /litre (4) 2×10^{-5} mole/litre

Q.85 Let the solubilities of AgCl in pure water, 0.01 M $CaCl_2$, 0.01 M NaCl & 0.05 M $AgNO_3$ be s_1, s_2, s_3 & s_4 respectively what is the correct order of these quantities . Neglect any complexation.
(1) $s_1 > s_2 > s_3 > s_4$ (2) $s_1 > s_2 = s_3 > s_4$
(3) $s_1 > s_3 > s_2 > s_4$ (4) $s_4 > s_2 > s_3 > s_1$

Q.86 The solubility product of $BaCrO_4$ is 2.4×10^{-10} M^2. The maximum concentration of $Ba(NO_3)_2$ possible without precipitation in a 6×10^{-4} M K_2CrO_4 solution is
(1) 4×10^{-7} M (2) 1.2×10^{10} M
(3) 6×10^{-4} M (4) 3×10^{-4} M.

Q.87 What is the solubility of $Al(OH)_3$, ($K_{sp} = 1 \times 10^{-33}$) in a buffer solution pH = 4 ?
(1) 10^{-3} M (2) 10^{-6} M
(3) 10^{-4} M (4) 10^{-10} M.

Q.88 The solubility of $Fe(OH)_3$ would be maximum in
(1) 0.1 M NaOH (2) 0.1 M HCl
(3) 0.1 M KOH (4) 0.1 M H_2SO_4.

Q.89 Arrange in increasing order of solubility of AgBr in the given solutions.
(i) 0.1 M NH_3 (ii) 0.1 M $AgNO_3$
(iii) 0.2 M NaBr (iv) pure water
(1) (iii) < (ii) < (iv) < (i)
(2) (iii) < (ii) < (i) < (iv)
(3) (iii) < (ii) = (i) < (iv)
(4) (ii) < (iii) < (iv) < (i)

Q.90 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:
(1) 5.0×10^{-5} (2) 5.0×10^{15}
(3) 5.0×10^{-15} (4) 0.2×10^{5}

EXERCISE-III

MCQ/STATEMENT/COMPREHENSION/MATCHING

Q.1 The two equilibria, $AB \rightleftharpoons A^+ + B^-$ and $AB + B^- \rightleftharpoons AB_2^-$ are simultaneously maintained in a solution with equilibrium constants, K_1 and K_2 respectively. If $[A^+]$ and $[AB_2^-]$ are y and x respectively, under equilibrium produced by adding the substance $AB(s)$ to the solvents, then

(A) $k_1/k_2 = \dfrac{y}{x}(y-x)^2$ (B) $k_1/k_2 = \dfrac{y}{x}(x-y)$

(C) $[B^-]_{eq.} = y - x$ (D) None of these

Q.2 Which of the following statements is (are) correct ?
(A) An irreversible reaction goes to almost completion.
(B) a reversible reaction always goes to completion if carried out in a closed vessel
(C) At equilibrium, the rate of forward reaction becomes equal to that of backward reaction.
(D) In the beginning, the rate of backward reaction is much greater than that of forward reaction.

Q.3 (i) $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$; K_1

(ii) $\left(\dfrac{1}{2}\right)N_2(g) + \left(\dfrac{1}{2}\right)O_2(g) \rightleftharpoons NO(g)$; K_2

(iii) $2NO(g) \rightleftharpoons N_2(g) + O_2(g)$; K_3

(iv) $NO(g) \rightleftharpoons \left(\dfrac{1}{2}\right)N_2(g) + \left(\dfrac{1}{2}\right)O_2(g)$; K_4

Correct relation between K_1, K_2 and K_4 is/are :

(A) $K_1 \times K_3 = 1$ (B) $\sqrt{K_1} \times K_4 = 1$

(C) $\sqrt{K_3} \times K_2 = 1$ (D) None

Q.4 The value of equilibrium constant of a reversible reaction at a given temperaure :
(A) depends on the initial concentration of reactants
(B) depends on the concentration of products at equilibrium
(C) gets reversed when the mode of representation of the reaction is reversed.
(D) changes when the unit of active mass is changed.

Q.5 Which of the following statement is (are) correct ?
(A) The value of equilibrium constant for a particular reaction is constant under all conditions of temperature and pressure.
(B) The unit of K_C for the reaction.
    $H_2O(l) \rightleftharpoons H_2O(g)$ are mol L^{-1}
(C) In the reaction
$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$. $[CaCO_3] = [CaO] = 1$
(D) K_p is always greater than K_c for a particular reaction.

Q.6 When $NaNO_3$ is heated in a closed vessel, oxygen is liberated and $NaNO_2$ is left behind. At equilibrium,

$NaNO_3(s) \rightleftharpoons NaNO_2(s) + \dfrac{1}{2}O_2(g)$

(A) addition of $NaNO_2$ favours reverse reaction
(B) addition of $NaNO_3$ favours forwards reaction
(C) increasing temperature favours forward reaction
(D) increasing pressure favours reverse reaction

Q.7 For the gas phase exothermic reaction.
$A_2 + B_2 \rightleftharpoons C_2$, carried out in a closed vessel, the equilibrium moles of A_2 can be increased by
(A) increasing the temperature
(B) decreasing the pressure
(C) adding inert gas at constant pressure
(D) removing some C_2

Q.8 Consider the equilibrium $HgO(s) + 4I^-(aq) + H_2O(l)$ $\rightleftharpoons HgI_4^{2-}(aq) + 2OH^-(aq)$, which changes will decrease the equilibrium concentration of HgI_4^{2-}
(A) Addition of 0.1 M HI (aq)
(B) Addition of HgO(s)
(C) Addition of $H_2O(l)$
(D) Addition of KOH (aq)

Q.9 For the reaction $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$, the forward reaction at constant temperature is favoured by
(A) introducing an inert gas at constant volume
(B) introducing chlorine gas at constant volume
(C) introducing an inert gas at constant pressure
(D) introducing PCl_5 at constant volume.

Q.10 When $NaNO_3(s)$ is heated in a closed vessel, oxygen is liberated and $NaNO_2(s)$ is left behind. At equilibrium.
(A) addition of $NaNO_2$ favours reverse reaction
(B) addition of $NaNO_3$ favours forward reaction
(C) increasing temperature favours forward reaction
(D) increasing pressure favours reverse reaction

Q.11 For the reaction : $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$
The forward reaction at constant temperature is favoured by
(A) introducing chlorine gas at constant volume
(B) introducing an inert gas at constant pressure
(C) increasing the volume of the container
(D) introducing PCl_5 at constant volume

Q.12 The reactions

$$PCl_5\,(g) \rightleftharpoons PCl_3\,(g) + Cl_2\,(g) \text{ and } COCl_2\,(g)$$
$$\rightleftharpoons CO(g) + Cl_2(g)$$

are simultaneously in equilibrium in an equilibrium box at constant volume. A few moles of CO(g) are later introduced into the vessel. After some time, the new equilibrium concentration of
(A) PCl_5 will remain unchanged
(B) Cl_2 will be greater
(C) PCl_5 will become less
(D) PCl_3 will become greater

Q.13 An industrial fuel, 'water gas', which consists of a mixture of H_2 and CO can be made by passing steam over red-hot carbon. The reaction is

$$C(s) + H_2O(g) \rightleftharpoons CO(g) + H_2(g), \Delta H = +131\text{ kJ}$$

The yield of CO and H_2 at equilibrium would be shifted to the product side by :
(A) raising the relative pressure of the steam
(B) adding hot carbon
(C) raising the temperature
(D) reducing the volume of the system

Q.14 For the equilibrium $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$, $\Delta H = -198$ kJ, the equilibrium concentration of SO_3 will be affected by
(A) doubling the volume of the reaction vessel
(B) increasing the temperature at constant volume
(C) adding more oxygen to the reaction vessel
(D) adding helium to the reaction vessel at constant volume

Q.15 Which of the following statements are correct at 25°C.
(A) pK_a for H_3O^+ is 15.74
(B) pK_b for OH^- is -1.74
(C) $pK_a + pK_b = pK_w$ for HCl & ClOH
(D) degree of dissociation of water is 1.8×10^{-7} %

Q.16 K_w of H_2O at 373 K is 1×10^{-12}. Identify which of the following is/are correct.
(A) pK_w of H_2O is 12
(B) pH of H_2O is 6
(C) H_2O is neutral
(D) H_2O is acidic

Q.17 Which of the following statement(s) is/are correct?
(A) the pH of 1.0×10^{-8} M solution of HCl is 8
(B) the conjugate base of $H_2PO_4^-$ is HPO_4^{2-}
(C) autoprotolysis constant of water increases with temperature
(D) When a soltion of a weak monoprotic acid is titrated again a strong base, at half -neutralization point pH = (1/2) pKa.

Q.18 Which of following can act as buffer ?
(A) NaCl + NaOH
(B) Borax + Boric acid
(C) $NaH_2PO_4 + Na_2HPO_4$
(D) $NH_4Cl + NH_4OH$.

Q.19 Equal volumes of following solutions are mixed, in which case the pH of resulting solution will be average value of pH of two solutions.
(A) Aqeous HCl of pH = 2, aqueous NaOH of pH = 12
(B) Aqeous HCl of pH = 2, aqueous HCl of pH = 4
(C) Aqeous NaOH of pH = 12, aqueous NaOH of pH = 10
(D) Aqeous CH_3COOH of pH = 5, aqueous NH_3 of pH = 9. [K_a (CH_3COOH) = K_b (NH_3)]

Q.20 A solution contains HCl, $Cl_2HC\ COOH$ & CH_3COOH at concentation 0.09 M in HCl, 0.09 M in $Cl_2HC\ COOH$ & 0.1 M in CH_3COOH. pH for the solution is 1. Ionization constant of $CH_3COOH = 10^5$. What is the magnitude of K for dichloroacetic acid ?
(A) $K_a = 1.25 \times 10^{-2}$ (B) $K_a = 2.25 \times 10^{-2}$
(C) $K_a = 3.75 \times 10^{-4}$ (D) $K_a = 5.75 \times 10^{-2}$

Q.21 A solution of chloroacetic acid, $ClCH_2COOH$ containing 9.45 grams in 500 ml of the solution has a pH of 2.0. What is the degree of ionization the acid.
(A) $\alpha = 0.09$ (B) $\alpha = 0.05$
(C) $\alpha = 0.07$ (D) $\alpha = 0.15$

Q.22 Which of the following solutions when added to 1L of a 0.01 M CH_3COOH solution will cause no change in the degree of dissociation of CH_3COOH and pH of the solution ? $K_a = 1.6 \times 10^{-5}$ for CH_3COOH?
(A) 0.6 mM HCOOH ($K_a = 8 \times 10^{-4}$)
(B) 0.1 M CH_3COONa
(C) 0.4 mM HCl
(D) 0.01 M CH_3COOH

Q.23 100 ml of 0.5M hydrazoic acid (HN_3, $K_a = 3.6$ x 10^{-4}) and 400ml of 0.1M cyanic acid (HOCN, $K_a = 8 \times 10^{-4}$) are mixed. which of the following is (are) true for the final solution?
(A) $[H^+] = 10^{-2}$ M
(B) $[N_3^-] = 3.6$ x 10^{-3} M
(C) $[OCN^-] = 6.4$ x 10^{-3} M
(D) $[H^+] = 1.4$ x 10^{-2} M

Q.24 K_a values for HA, HB and HD are 10^{-5}, 10^{-7} and 10^{-9} respectively. Which of the following will be correct for decimolar aqueous solutions of NaA, NaB and NaD at 25°C?
(A) $(pH)_{NaA} < (pH)_{NaB}$ (B) $(pH)_{NaD} < (pH)_{NaB}$
(C) $(pH)_{NaA} < (pH)_{NaD}$ (D) $(pH)_{NaB} = 7$

Q.25 0.1 M CH_3COOH is diluted at 25°C ($K_a = 1.8 \times 10^{-5}$), then which of the following will be found correct
(A) [H⁺] will increase
(B) pH will increase
(C) number of H⁺ will increase
(D) all the above are correct

Q.26 Degree of hydrolysis for a salt of strong acid and weak base is
(A) independent of dilution
(B) increases with dilution
(C) increases with decrease in K_b of the bases
(D) decreases with decrease in temperature.

Q.27 When 0.1 mol arsenic acids (H_3AsO_4) is dissolved in 1L buffer solution of pH = 8, which of the following hold good? For arsenic acid $K_1 = 2.5 \times 10^{-4}$, $K_2 = 5 \times 10^{-8}$, $K_3 = 2 \times 10^{-13}$. ['<<' sign denotes that the high concentration is at least more than 100 times the lower one]
(A) $[H_3AsO_4] << [H_2AsO_4^-]$
(B) $[H_2AsO_4^-] << [HAsO_4^{2-}]$
(C) $[HAsO_4^{2-}] << [H_2AsO_4^-]$
(D) $[AsO_4^{3-}] << [HAsO_4^{2-}]$

Q.28 Which of the following mixtures will act as buffer ?
(A) H_2CO_3 + NaOH (1.5 : 1 molar ratio)
(B) H_2CO_3 + NaOH (1.5 : 2 molar ratio)
(C) NH_4OH + HCl (5 : 4 molar ratio)
(D) NH_4OH + HCl (4 : 5 molar ratio)

Q.29 Which of the following is/are correct regarding buffer solution ?
(A) It contains weak acid and its conjugate base
(B) It contains weak base and its conjugate acid
(C) It shows large change in pH on adding small amount of acid or base.
(D) All of the above.

Q.30 Let the colour of the indicator HIn (colourless) will be visible only when its ionised form (pink) is 25% or more in a solution. Suppose HIn ($pK_a = 9.0$) is added to a solution of pH = 9.6 predict what will happen. (Take log 2 = 0.3)
(A) pink colour will be visible
(B) pink colour will not be visible
(C) % of ionised form will be less than 25%
(D) % of ionised form will be more than 25%

Q.31 A 2.5 gm impure sample containing weak monoacidic base (Mol. wt. = 45) is dissolved in 100 ml water and titrated with 0.5 M HCl when $\left(\dfrac{1}{5}\right)^{th}$ of the base was neutralised the pH was found to be 9 and at equivalent point pH of solution is 4.5. Given : All data at 25° C & log 2 = 0.3. Select **correct** statement(s).
(A) K_b of base is less than 10^{-6}
(B) Concentration of salt (C) at equivalent point is 0.25 M
(C) Volume of HCl is used at equavalent point is 100 ml
(D) Weight percentage of base in given sample is 80%

Q.32 In which of the following solutions, the solubility of AgCN will be greater than that in pure water :
Given $K_{sp}(AgCN) = 4 \times 10^{-16}$, $K_a(HCN) = 5 \times 10^{-10}$
(A) 0.01 M Ag NO_3 solution
(B) A buffer solution of pH = 12
(C) 0.2 M NH_3 solution
(D) A buffer solution of pH = 5

Q.33 The solubility of a sparingly soluble salt $A_x B_y$ in water at 25°C = 1.4×10^{-4} M. The solubility product is 1.1×10^{-11}. The possibilities are
(A) x = 1, y = 2   (B) x = 2, y = 1
(C) x = 1, y = 3   (D) x = 3, y = 1

Q.34 Which of the following are true for an acid–base titration ?
(A) Indicators catalyse the acid base reactions by releasing or accepting H⁺ ions.
(B) Indicators do not significantly affect the pH of the solution to which they are added.
(C) Acid–base reactions do not occur in absence of indicators.
(D) Indicators have different colours in dissociated and undissociated forms.

Q.35 If K_{a1} and K_{a2} of H_2SO_4 are 10^{-2} and 10^{-6} respectively then
(A) $K_{a1} > K_{a2}$ because it is easy to abstract H⁺ from H_2SO_4 and less easy to abstract H⁺ from HSO_4^-.
(B) K_{a1} and K_{a2} may be measured in acetic acid.
(C) K_{a1} and K_{a2} are measured in H_2O.
(D) the H⁺ ion conc. of 0.01 M H_2SO_4 will be less than 0.02 M.

Comprehension # 1

4.4 grams of CO_2 are introduced into a 0.82 L flask containing excess solid carbon at 627°C, so that the equilibrium

$$CO_2(g) + C(s) \rightleftharpoons 2CO(g)$$
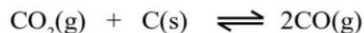
is reached.

The density of equilibrium gaseous mixture corresponds to an average molecular weight of 36.

For the above reaction

$$K_P = \frac{P_{CO}^2}{P_{CO_2}} \text{ and } K_C = \frac{[CO]^2}{[CO_2]}$$

[R = 0.082 lt- atm/ mol- K ; C = 12, O = 16]

Q.36 Total number of moles of equilibrium gasesous mixture is

(A) $\frac{1}{30}$ (B) $\frac{2}{15}$ (C) $\frac{1}{15}$ (D) $\frac{1}{10}$

Q.37 K_P of the reaction $C(s) + CO_2(g) \rightleftharpoons 2CO(g)$ is
(A) 6 atm (B) 12 atm (C) 24 atm (D) 15 atm

Q.38 If in the above problem where actually 1.2 g of solid carbon present initially, how many total moles of CO_2 would have to be introduced initially so that at equilibrium only a trace of carbon remained ?
(A) 0.25 (B) 0.7 (C) 0.6 (D) 0.4

Comprehension # 2

Le chatelier's principle

If a system at equilibrium is subjected to a change of any one of the factors such as concentration, pressure or temperature, the system adjusts itself in such a way as to Nulify the effect of that change.

Change of pressure : If a system in equilibrium consists of gases, then the concentrations of all the components can be altered by changing the pressure. To increase the pressure on the system, the volume has to be decreased proportionately. The total number of moles per unit volume will now be more and the equilibirum will shift in the direction in which there is decrease in number of moles i.e., towards the direction in which there can be decrease in pressure .

Effect of pressure on melting point : There are two types of solids :

(a) Solids whose volume decreases on melting, e.g., ice, diamond, carborundum, magnesium nitride and quartz.

Solid (higher volume) $\rightleftharpoons$ Liquid (lower volume)
The process of melting is facilitated at high pressure, thus melting point is lowered.

(b) Solids whose volume increase on melting, e.g., Fe, Cu, Ag, Au, etc.

Solid (lower volume) $\rightleftharpoons$ Liquid (higher volume)
In this case the process of melting become difficult at high pressure; thus melting point becomes high.

(c) **Solubility of substances :** When solid substance are dissolved in water, either heat is evolved (exothermic) or heat is absorbed (endothermic).

$$KCl + aq \rightleftharpoons KCl(aq) - heat$$

In such cases, solubility increase with increase in temperature. Consider the case of KOH; when this is dissolved, heat is evolved.

$$KOH + aq \rightleftharpoons KOH(aq) + heat$$

In such cases, solubility decrease with increase in temperature.

(d) **Solubility of gases in liquids :** When a gas dissolves in liquid, there is decrease in volume. Thus, increase of pressure will favour the dissolution of gas in liquid.

Q.39 A gas 'X' when dissolved in water heat is evolved. Then solublity of 'X' will increase :
(A) Low pressure, high temperature
(B) Low pressure, low temperature
(C) high pressure, high temperature
(D) high pressure, low temperature

Q.40 $Au(s) \rightleftharpoons Au(\ell)$
Above equilibrium is favoured at :
(A) High pressure low temperature
(B) High pressure high temperature
(C) Low pressure, high temperature
(D) Low pressure, low temperature

Q.41 For the reaction, $\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons NO(g)$

If pressure is increased by reducing the volume of the container then :
(A) Total pressure at equilibrium will change.
(B) Concentration of all the component at equilibrium will change.
(C) Concentration of all the component at equilibrium will remain same
(D) Equilibrium will shift in the forward direction

Comprehension # 3

If we know the equilibrium constant for a particular reaction, we can calculate the concentrations in the equilibrium mixture from the initial ocncentrations. Commonly only the initial concentration of reactants are given.

Q.42 In a study of equilibrium

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

1 mole of H_2 and 3 mole of I_2 gave rise at equilibrium to x mol of HI.

Addition of a further 2 mol of H_2 gave an additional x mol of HI. What is x ?

(A) 0.5   (B) 1

(C) 1.5   (D) None of these

Q.43 In above prolem, what is K_p at the temperature of the experiment.

(A) 1   (B) 2

(C) 4   (D) None of these

Q.44 In a study of equilibrium

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

Starting with 2 mole SO_2 and 1.5 mole O_2 in 5 litre flask. Equilibrium mixture required 0.4 mole $KMnO_4$ in acidic medium. Hence K_c is :

(A) 0.2   (B) 5.0

(C) 675.0   (D) None of these

Comprehension # 4

Consider a solution of CH_3COONH_4 which is a salt of weak acid & weak base.

The equilibrium involved in the solutions are :

$$CH_3COO^- + H_2O \rightleftharpoons CH_3COOH + OH^- \quad\ldots\ldots(1)$$
$$NH_4^- + H_2O \rightleftharpoons NH_4OH + H^+ \quad\ldots\ldots(2)$$
$$H^+ + OH^- \rightleftharpoons H_2O \quad\ldots\ldots(3)$$

If we add these three reactions, then the net reaction is

$$CH_3COO^- + NH_4^+ + H_2O$$
$$\rightleftharpoons CH_3COOH + NH_4OH \quad\ldots\ldots(4)$$
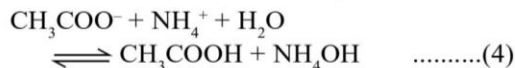
Both CH_3COO^- and NH_4^+ get hydrolysed independently and their hydrolysis depends on

(i) their initial concentration

(ii) the value of K_h which is $\dfrac{K_w}{K_a}$ for CH_3COO^- and

$\dfrac{K_w}{K_b}$ for NH_4^+.

Since both of the ions were produced from the same salt, their initial concentrations are same. Therefore

unless & untial the value of $\dfrac{K_w}{K_a}$ and $\dfrac{K_w}{K_b}$ or K_a and

K_b is same, the degree of hydrolysis of ion can't be same.

To explain why we assume that degree of hydrolysis of cation and anion is same, we need to now look at the third reaction i.e., combination of H^+ and OH^- ions.

It is obvious that this reaction happens only because

one reaction produced H^+ ion and the other produced OH^- ions. We can also note that this reaction causes both the hydrolysis reaction to occur more since their product ions are being consumed. Keep this thing in mind that the equilibrium which has smaller value of equilibrium conxtant is affected more by the common ion effect. For the same reason if for any reason a reaction is made to occur to a greater extent by the comsumption of any one of the product ion, the reaction with the smaller value of equilibrium constant tends to get affected more.

Therefore we conclude that firstly the hydrolysis of both the ions ocurs more in the presence of each other (due to consumption of the product ions) than in each other is absence. Secondly the hydrolysis of the ion which occurs to a lesser extent (due to smaller value of K_h) is affected more than the one whose K_h is greater. Hence we can see that the degree of hydrolysis of both the ions would be close to each other when they are getting hydrolysed in the presence of each other.

Q.45 In the hydrolysis of salt of weak acid & weak base :

(A) degree of hydrolysis of cation and anion is different

(B) degree of hydrolysis of cation and anion is same

(C) degree of hydrolysis of cation and anion is different and they can never be assumed same.

(D) degree of hydrolysis of cation and anion is different but they are very close to each other when they are getting hydrolysed in the presence of each other.

Q.46 For 0.1 M CH_3COONH_4 salt solution given, K_a $(CH_3COOH) = K_b (NH_4OH) = 2 \times 10^{-5}$.

In this case : degree of hydrolysis of cation and anion are

(A) exactly same

(B) slightly different

(C) can't say

(D) different but can be take approximatly same

Q.47 In a solution of $NaHCO_3$, the amphiprotic anion can undergo ionization to form H^+ ion and hydrolysis to form OH^- ion.

$$HCO_3^- + H_2O \xrightleftharpoons{\text{ionization}} CO_3^{2-} + H_2O$$

$$HCO_3^- + H_2O \xrightleftharpoons{\text{hydrolysis}} H_2CO_3 + OH^-$$
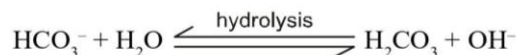
To calculat pH, suitable approximation is :

(A) $[CO_3^{2-}] = [H_2CO_3]$

(B) degree of ionization = degree of hydrolysis

(C) both (A) and (B)

(D) neither 'A' nore 'B'

Comprehension # 5

Strontium fluoride (SrF_2) is a sparingly soluble salt. Let s_1 be its solubility (in mol/lt.) in pure water at 25°C, assuming no hydrolysis of F^- ions. Also, let s_2 be its solubility (in mol/lt.) in 0.1 M NaF solution at 25°C, assuming no hydrolysis of F^- ions and no complex formation.

However, it is known that $s_1 : s_2 = 10^6 : 256$. Now, answer the following questions.

Q.48 The K_{sp} value of SrF_2 at 25°C is :

(A) 2.048×10^{-9} (B) 1.372×10^{-9} (C) 1.864×10^{-9} (D) 2.916×10^{-9}

Q.49 The mass of NaF to be added to 100 ml solution of 0.0011 M Sr^{+2} ions to reduce its concentration to 2×10^{-4} M is :
[Assume no hydrolysis of F^- ions]

(A) 0.42 g   (B) 0.063 g   (C) 0.021 g   (D) 0.084 g

Q.50 The solubility of SrF_2 (in mol/L) in a buffer solution of pH =5 at 25°C is : [Given : K_a for HF = $\frac{1}{7} \times 10^{-5}$]

(A) 1.6×10^{-3} (B) 3.2×10^{-3} (C) 4.8×10^{-3} (D) 6.4×10^{-3}

Q.51 Match the following

Column I	Column II
(A) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ (t = 300ºC)	(p) $\Delta n_g > 0$
(B) $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ (t = 50ºC)	(q) $K_p < K_c$
(C) $C(s) + H_2O(g) \rightleftharpoons CO(g) + H_2(g)$	(r) K_p not defined
(D) $CH_3COOH(\ell) + C_2H_5OH(\ell) \rightleftharpoons CH_3COOC_2H_5(\ell) + H_2O(\ell)$	(s) $P_{initial} > P_{eq.}$

Q.52

Column-I	Column-II Kp/Kc
(A) $A_{2(g)} + 3B_{2(g)} \rightleftharpoons 2AB_{3(g)}$	(p) $(RT)^{-2}$
(b) $A_{2(g)} + B_{2(g)} \rightleftharpoons 2AB_{(g)}$	(q) $(RT)^0$
(C) $A_{(s)} + 1.5B_{2(g)} \rightleftharpoons 2AB_{3(g)}$	(r) $(RT)^{½}$
(D) $AB_{2(g)} \rightleftharpoons AB_{(g)} + 0.5B_{2(g)}$	(s) $(RT)^{-½}$

Q.53

Column-I	Column-II factors affecting forward direction
(A) $A_{2(g)} + B_{2(g)} \xrightleftharpoons{Exothermic} 2AB_{(g)}$	(p) High temperature
(B) $2AB_{2(g)} + B_{2(g)} \xrightleftharpoons{Exothermic} 2AB_{3(g)}$	(q) Low temperature
(C) $2AB_{3(g)} \xrightleftharpoons{Exothermic} A_{2(g)} + 3B_{2(g)}$	(r) High pressure
	(s) Low pressure
	(t) Independent of pressure

Q.54

Column I	Column II	
(A) $K_p < K_c$	(P)	$N_2 + 3H_2 \rightleftharpoons 2NH_3$
(B) Introduction	(Q)	$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ of inert gas at pressure will decrease the constant concentration of reactants.
(C) K_p^0 is dimensionless	(R)	$2NO_2(g) \rightleftharpoons N_2O_4(g)$
(D) Temperature increase	(S)	$NH_3(g) + HI(g) \rightleftharpoons$ will shift the reaction $NH_4I(s)$ on product side.

Q.55 Column-I (pH of the resultant solution) | Column-II (Exist b/w colour transition range of an indicator)

(A) 200 ml of H_2SO_4 solution (specific gravity 1.225 containing 25% H_2SO_4 by weight) + 800 ml of 0.525M strong triacidic base $X(OH)_3$

(P) Phenol Red (6.8 to 8.4)

(B) 50 ml of 0.1 M HCO_3^- + 50 ml of 0.8 M CO_3^{2-}

$(H_2CO_3: K_{a_1} = 4 \times 10^{-7}, K_{a_2} = 2 \times 10^{-11})$

(Q) Propyl red (4.6 to 6.4)

(R) Phenolphthalein (8.3 to 10.1)

(C) 50 ml of 0.2 M HA(aq) $(K_a = 10^{-5})$ + 50 ml of 0.1 M HCl(aq) + 100 ml of 0.13 M NaOH(aq)

(S) Malachite green (11.4 to 13)

NUMERICAL VALUE BASED

Q.56 Find the value of K_p for the reaction

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ is 50. What is the value of K_c

Q.57 The equilibrium constant of the reaction $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ is 64. If the volume of the container is reduced to one fourth of its original volume find the value of the equilibrium constant

Q.58 The equilibrium constant (K_p) for the reaction $PCl_5(g) \rightarrow PCl_3(g) + Cl_2(g)$ is 16. If the volume of the container is reduced to one half its original volume find the value of K_p for the reaction at the same temperature

Q.59 An unknown compound A dissociates at 500ºC to give products as follows -

$A(g) \rightleftharpoons B(g) + C(g) + D(g)$

Vapour density of the equilibrium mixture is 50 when it dissociates to the extent to 10%. What will be the molecular weight of Compound A –

Q.60 In an equilibrium reaction for which $\Delta G° = 0$, the equilibrium constant K =

Q.61 Calculate the percentage of hydrolysis in a 0.0100 M solution of KCN.$(K_a = 6.2 \times 10^{-10})$

Q.62 Calculate the ratio of degree of dissociation (α_2/α_1) when 1 M acetic acid solution is diluted to 100 times. [Given $K_a = 10^{-5}$ M]

Q.63 Dissociation constant for a weak base BOH is 10^{-5}. calculate the value of pH when it is half neutralized by HCl?

Q.64 Dissociation of H_3PO_4 takes place in following steps

Q.65 A solution with pH 2.0 is more acidic than the one with pH 6.0 by a factor of :

JEE-MAIN
PREVIOUS YEAR'S
CHEMICAL EQUILIBRIUM

Q.1 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 :

[JEE Main-2016]

(1) 0.818   (2) 1.818

(3) 1.182   (4) 0.182

Q.2 Which of the following lines correctly show the temperature dependence of equilibrium constant, K, for an exothermic reaction ? **[JEE Main-2018]**
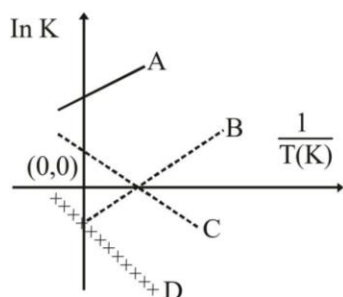
(1) B and C   (2) C and D
(3) A and D   (4) A and B

Q.3 5. 1 g NH_4SH is is introduced in 3.0 L evacuated flask at 327°C. 30% of the solid NH_4SH decomposed to NH_3 and H_2S as gases. the K_p of the reaction at 327°C is ($R = 0.082$ L atm mol^{-1} K^{-1}, Molar mass of S = 32 g mol^{-1}, molar mass of N = 14 g mol^{-1})

[JEE Main - 2019(January)]

(1) 0.242×10^{-4} atm^2 (2) 1×10^{-4} atm^2
(3) 4.9×10^{-3} atm^2 (4) 0.242 atm^2

Q.4 For the chemical reaction $X \rightleftharpoons Y$, the standard reaction Gibbs energy depends on temperature T (in K) as $\Delta_r G°(\text{inkJmol}^{-1}) = 120 - \frac{3}{8}T$.

The major component of the reaction mixture at T is:

[JEE Main-2019(January)]

(1) Y if T = 300 K   (2) Y if T = 280 K
(3) X if T = 350 K   (4) X if T = 315 K
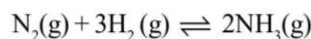
Q.5 Consider the reaction
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
The equilibrium constant of the above reaction is K_p. If pure ammonia is left to dissociate, the partial pressure of ammonia at equilibrium is given by (Assume that $P_{NH_3} << P_{total}$ at equilibrium)

[JEE Main-2019(January)]

(1) $\dfrac{3^{3/2} K_p^{1/2} P^2}{16}$ (2) $\dfrac{K_p^{1/2} P^2}{16}$

(3) $\dfrac{K_p^{1/2} P^2}{4}$ (4) $\dfrac{3^{3/2} K_p^{1/2} P^2}{4}$

Q.6 Consider the following reversible chemical reactions:

$A_2(g) + B_2(g) \xrightleftharpoons{K_1} 2AB(g)$ .....(1)

$6AB(g) \xrightleftharpoons{K_2} 3A_2(g) + 3B_2(g)$ .....(2)
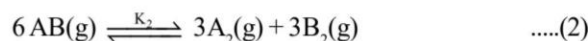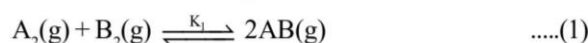
The relation between K_1 and K_2 is

[JEE Main-2019(January)]

(1) $K_1K_2 = \dfrac{1}{3}$ (2) $K_2 = K_1^3$

(3) $K_2 = K_1^{-3}$ (4) $K_1K_2 = 3$

Q.7 In a chemical reaction $A + 2B \xrightleftharpoons{K} 2C + D$, the initial concentration of B was 1.5 times of A but the equilibrium concentrations of A and B were found to be equal. The equilibrium, constant(K) for the aforesaid chemical reaction is **[JEE Main-2019 (January)]**
(A) 4   (B) 16
(C) 1/4   (D) 1

Q.8 Two solids dissociate as follows

$A(s) \rightleftharpoons B(g) + C(g); K_{P1} = x$ atm^2

$D(s) \rightleftharpoons C(g) + E(g); K_{P2} = y$ atm^2
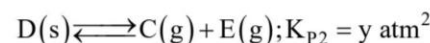
The total pressure when both the solids dissociate simultaneously is **[JEE Main-2019(January)]**

(A) $\sqrt{x+y}$ atm

(B) $2\left(\sqrt{x+y}\right)$ atm

(C) $(x+y)$ atm

(D) $x^2 + y^2$ atm

Q.9 The value of K_p/K_c for the following reactions at 300 K are respectively: **[JEE Main-2019 (January)]**
(At 300 K, RT = 24.62 dm³ atm mol⁻¹)

$N_2(g) + O_2(g) = 2NO(g)$

$N_2O_4(g) = 2NO_2(g)$

$N_2(g) + 3H_2(g) = 2NH_3(g)$
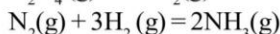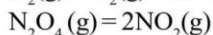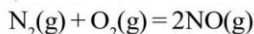
(1) 1, 24.62 dm³ atm mol⁻¹, 606.0 dm⁶ atm² mol⁻²

(2) 1, 24.62 dm³ atm mol⁻¹, 1.65 dm⁻⁶ atm⁻² mol²

(3) 1, 4.1×10⁻² dm⁻³ atm⁻³ mol, 606.0 dm⁶ atm² mol⁻²

(4) 24.62 dm³ atm mol⁻¹, 606.0 dm⁶ atm² atm² mol⁻², 1.65×10⁻³ dm⁻⁶ atm⁻² mol²

Q.10 For the following reactions, equilibrium constants are given : **[JEE Main-2019 (April)]**

$S(s) + O_2(g) \rightleftharpoons SO_2(g)$; $K_1 = 10^{52}$

$2S(s) + 3O_2(g) \rightleftharpoons 2SO_3(g)$; $K_2 = 10^{129}$

The equilibrium constant for the reaction,

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ is :
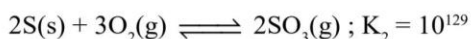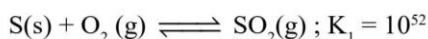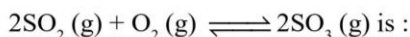
(1) 10^{181} (2) 10^{154}

(3) 10^{25} (4) 10^{77}

Q.11 The INCORRECT match in the following is : **[JEE Main-2019 (April)]**

(1) $\Delta G^o < 0$, K < 1 (2) $\Delta G^o < 0$, K = 1

(3) $\Delta G^o > 0$, K < 1 (4) $\Delta G^o < 0$, K > 1

Q.12 In which one of the following equilibria, $K_p \neq K_c$? **[JEE Main-2019 (April)]**

(1) $NO_2(g) + SO_2(g) \rightleftharpoons NO(g) + SO_3(g)$

(2) $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$

(3) $2NO(g) \rightleftharpoons N_2(g) + O_2(g)$

(4) $2C(s) + O2(g) \rightleftharpoons 2CO(g)$

Q.13 For the reaction,

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$,
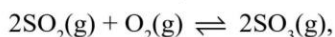
$\Delta H = -57.2$ kJ mol⁻¹ and

$K_c = 1.7 \times 10^{16}$

Which of the following statement is INCORRECT? **[JEE Main-2019 (April)]**

(1) The equilibrium constant is large suggestive of reaction going to completion and so no catalyst is required.

(2) The equilibrium will shift in forward direction as the pressure increase.

(3) The equilibrium constant decreases as the temperature increases.

(4) The addition of inert gas at constant volume will not affect the equilibrium constant.

Q.14 For the reaction, $2H_2(g) + 2NO(g) \rightarrow N_2(g) + 2H_2O(g)$; the observed rate expression is, rate = $k_f[NO]^2[H_2]$. **[JEE Main-2020 (January)]**

(1) $k_b[N_2][N_2O]$ (2) $k_b[N_2][H_2O]^2/[NO]$

(3) $k_b[N_2][H_2O]_2$ (4) $k_b[N_2][H_2O]^2$

Q.15 In the Figure shown below reactant A(represented by square) is an equilibrium with product B (represented by circle). The equilibrium constant is : **[JEE Main-2020 (January)]**
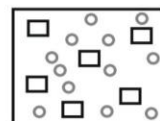
(1) 4 (2) 8

(3) 1 (4) 2

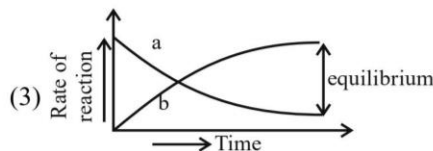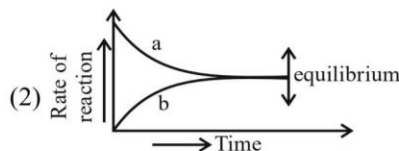**Q.16** If the equilibrium constant for A $\rightleftharpoons$ B + C is $K_{eq}^{(1)}$ and that of B + C $\rightleftharpoons$ P is $K_{eq}^{(2)}$, the equilibrium constant for A $\rightleftharpoons$ P is **[JEE Main-2020 (September)]**

(1) $K_{eq}^{(1)} / K_{eq}^{(2)}$ (2) $K_{eq}^{(1)} + K_{eq}^{(2)}$

(3) $K_{eq}^{(2)} - K_{eq}^{(1)}$ (4) $K_{eq}^{(1)} K_{eq}^{(2)}$

Q.17 For the equilibrium A $\rightleftharpoons$ B, the variation of the rate of the forward (a) and reverse (b) reaction with time is given by **[JEE Main-2020(September)]**
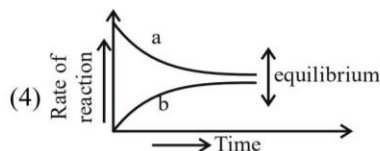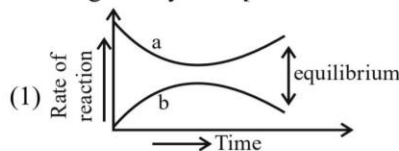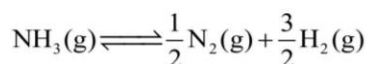
Q.18 For a reaction $X + Y \rightleftharpoons 2Z$, 1.0 mol of X, 1.5 mol of Y and 0.5 mol of Z were taken in a 1 L vessel and allowed to react. At equilibrium, the concentration of Z was 1.0 mol L^{-1}. The equilibrium constant of the reaction is _____ $\dfrac{x}{15}$. The value of x is _____. **[JEE Main-2020 (September)]**

Q.19 Consider the following reaction :
$N_2O_4(g) \rightleftharpoons 2NO_2 (g)$; $\Delta H^0 = + 58$ kJ
For each of the following cases (a, b), the direction in which the equilibrium shifts is : **[JEE Main-2020 (September)]**
(a) Temperature is decreased
(b) Pressure is increased by adding N_2 at constant T.
(1) (a) Towards product, (b) towards reactant
(2) (a) Towards reactant, (b) no change
(3) (a) Towards reactant, (b) towards product
(4) (a) Towards product, (b) no change

Q.20 The value of K_C is 64 at 800 K for the reaction
$N_2(g) + 3H_2 (g) \rightleftharpoons 2NH_3 (g)$
The value of K_C for the following reaction is
$NH_3(g) \rightleftharpoons \dfrac{1}{2}N_2(g) + \dfrac{3}{2}H_2(g)$
[JEE Main-2020 (September)]
(1) 1/8 (2) 1/64
(3) 8 (4) 1/4
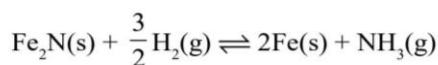
Q.21 For the reaction
$Fe_2N(s) + \dfrac{3}{2}H_2(g) \rightleftharpoons 2Fe(s) + NH_3(g)$
[JEE Main-2020 (September)]
(1) $K_C = K_p (RT)^{1/2}$ (2) $K_C = K_p (RT)$
(3) $K_C = K_p (RT)^{1/2}$ (4) $K_C = K_p (RT)^{-1/2}$

Q.22 How many statement are correct about the effect of addition of catalyst at constant temperature. **[JEE Main-2020 (September)]**
(1) The equilibrium constant will remains constant
(2) H of the reaction will remains constant
(3) K_f and K_b will increase up to same extent
(4) equilibrium composition will change

Q.23 In an experiment starting from 1 mol C_2H_5OH, 1 mol CH_3COOH and 1 mol of H_2O, the equilibrium mixture on analysis shows that 50% of acid was esterified; what will be $K_C = ?$
[JEE Main-2020 (September)]

IONIC EQUILIBRIUM

Q.24 Which of the following salts is the most basic in aqueous solution ? **[JEE Main-2018]**
(1) CH_3COOK (2) $FeCl_3$
(3) $Pb(CH_3COO)_2$ (4) $Al(CN)_3$

Q.25 An alkali is titrated against an acid with methyl orange as indicator, which of the following is a correct combination ? **[JEE Main-2018]**

	Base	Acid	End point
(1)	Strong	Strong	Pinkish red to yellow
(2)	Weak	Strong	Yellow to pinkish red
(3)	Strong	Strong	Pink to colourless
(4)	Weak	Strong	Colourless to pink

Q.26 An aqueous solution contains 0.10 M H_2OS and 0.20 M HCl. If the equilibrium constants for the formation of HS$^-$ from H_2S is 1.0×10^{-7} and that of S^{2-} from HS$^-$ ions is 1.2×10^{-13} then the concentration of S^{2-} ions in aqueous solution is : **[JEE Main-2018]**
(1) 3×10^{-20} (2) 6×10^{-21}
(3) 5×10^{-19} (4) 5×10^{-8}

Q.27 A aqueous solution contains an unknown concentration of Ba^{2+}. When 50 mL of a 1 M solution of Na_2SO_4 is added, BaSO just begins to precipitate. The final volume is 500 mL. The solubility product of BaSO 4 is the original concentration of Ba^{2+}?
[JEE Main-2018]
(1) 2×10^{-9} M
(2) 1.1×10^{-9} M
(3) 1.0×10^{-9} M
(4) 5×10^{-9} M

Q.28 A mixture of 100 m mol of Ca (OH)$_2$ and 2 g of sodium sulphate was dissolved in water and the volume was made upto 100 mL. The mass of calcium sulphate formed and the concentration of OH$^-$ in resulting solution, respectively are (Molar mass of Ca (OH)$_2$, Na_2SO_4 and $CaSO_4$ are 74, 143 and 136 g mol^{-1} respectively; K_{sp} of Ca (OH)$_2$, is 5.5×10^{-6}) **[JEE Main-2019 (January)]**
(1) 1.9 g, 0.28 mol L^{-1}
(2) 13.6 g, 0.28 mol L^{-1}
(3) 1.9 g, 0.14 mol L^{-1}
(4) 13.6 g, 0.14 mol L^{-1}

Q.29 If K_{sp} of Ag_2CO_3 is 8×10^{-12}, the molar solubility of Ag_2CO_3 in 0.1 M $AgNO_3$ is : **[JEE Main-2019(January)]**
(1) 8×10^{-12} M
(2) 8×10^{-11} M
(3) 8×10^{-10} M
(4) 8×10^{-13} M

Q.30 20 mL of 0.1 M H_2SO_4 is added to 30 mL of 0.2 M NH_4OH solution. The pH of the resultant mixture is [pk_b of $NH_4OH=4.7$] **[JEE Main-2019 (January)]**
(1) 5.2
(2) 9.0
(3) 5.0
(4) 9.4

Q.31 The pH of rain water is approximately
[JEE Main-2019 (January)]
(1) 5.6
(2) 7.5
(3) 7.0
(4) 6.5

Q.32 If solubility product of $Zr_3(PO_4)_4$ is denoted by K_{sp} and its molar solubility is denoted by S, then which of the following relation between S and K_{SP} is correct
[JEE Main-2019 (April)]

(1) $S = \left(\dfrac{K_{sp}}{929}\right)^{1/9}$
(2) $S = \left(\dfrac{K_{sp}}{216}\right)^{1/7}$

(3) $S = \left(\dfrac{K_{sp}}{144}\right)^{1/6}$
(4) $S = \left(\dfrac{K_{sp}}{6912}\right)^{1/7}$

Q.33 The molar solubility of $Cd(OH)_2$ is 1.84×10^{-5} M in water. The expected solubility of $Cd(OH)_2$ in a buffer solution of pH = 12 is :
[JEE Main-2019 (April)]
(1) 6.23×10^{-11} M
(2) 1.84×10^{-9} M

(3) $\dfrac{2.49}{1.84} \times 10^{-9}$ M

(4) 2.49×10^{-10} M

Q.34 What is the molar solubility of $Al(OH)_3$ in 0.2 M NaOH solution ? Given that, solubility product of $Al(OH)_3$ = 2.4×10^{-24} : **[JEE Main-2019 (April)]**
(1) 12×10^{-23}
(2) 12×10^{-21}
(3) 3×10^{-19}
(4) 3×10^{-22}

Q.35 The pH of a 0.02M NH_4Cl solution will be [given $Kb(NH_4OH) = 10^{-5}$ and log2= 0.301]
[JEE Main-2019 (April)]
(1) 4.65
(2) 5.35
(3) 4.35
(4) 2.65

Q.36 Two solutions, A and B, each of 100 L was made by dissolving 4g of NaOH and 9.8 g of H_2SO_4 in water, respectively. The pH of the resultant solution obtained from mixing 40 L of solution A and 10 L of solution B is_____.
[JEE Main-2020 (January)]

Q.37 3g of acetic acid is added to 250 mL of 0.1 M HCl and the solution made up to 500 mL. To 20 mL of this solution $\dfrac{1}{2}$ mL of 5 M NaOH is added. The pH of the solution is.

[JEE Main-2020 (January)]
[given: pKa of acetic acid = 4.75, molar mass of acetic acid = 60g/mol, log3 = 0.4771]
Neglect any changes in volume.

Q.38 The strength of an aqueous NaOH solution is most accurately determined by titrating : (Note : consider that an appropriate indicator is used)
[JEE Main-2020 (January)]
(1) Aq. NaOH in a volumetric flask and concentrated H_2SO_4 in a conical flask
(2) Aq. NaOH in a burette and aqueous oxalic acid in a conical flask
(3) Aq. NaOH in a pipette and aqueous oxalic acid in a burette
(4) Aq. NaOH in a burette and concentrated H_2SO_4 in a conical flask

Q.39 The stoichiometry and solubility product of a salt with the solubility curve given below is, respectively:
[JEE Main-2020 (January)]
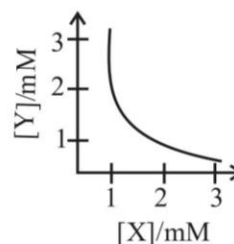
(1) X_2Y, 2×10^{-9} M³
(2) XY, 2×10^{-6} M³
(3) XY_2, 4×10^{-9} M³
(4) XY_2, 1×10^{-9} M³

Q.40 For the following Assertion and Reason, the correct option is :
**[JEE Main-2020 (January)]**
Assertion : The pH of water increases with increase in temperature.
Reason : The dissociation of water into H^+ and OH^- is an exothermic reaction.
(1) Assertion is not true, but reason is true.
(2) Both assertion and reason are false.
(3) Both assertion and reason are true, but the reason is not the correct explanation for the assertion.
(4) Both assertion and reason are true, and the reason is the correct explanation for the assertion.

Q.41 The K_{sp} for the following dissociation is 1.6×10^{-5}

[JEE Main-2020 (January)]

$$PbCl_2(s) \rightleftharpoons Pb^{2+}_{(aq)} + 2Cl^-_{(aq)}$$
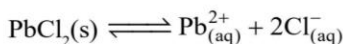
Which of the following choices is correct for a mixture of 300 mL 0.134 M $Pb(NO_3)_2$ and 100 mL 0.4 M NaCl?

(1) $Q = K_{sp}$

(2) $Q > K_{sp}$

(3) Not enough data provided

(4) $Q < K_{sp}$

Q.42 The solubility product of $Cr(OH)_3$ at 298 K is 6.0×10^{-31} The concentration of hydroxide ions in a saturated solution of $Cr(OH)_3$ will be:

[JEE Main-2020 (January)]

Q.43 For the following Assertion and Reason, the correct option is

Assertion (A): When Cu (II) and sulphide ions are mixed, they react together extremely quickly to give a solid.

Reason (R): The equilibrium constant of $Cu^{2+}(aq) +$

$S^{2-}(aq) \rightleftharpoons CuS(s)$ is high because the solubility product is low.

[JEE Main-2020 (September)]

(1) (A) is false and (R) is true.

(2) Both (A) and (R) are true but (R) is not the explanation for (A).

(3) Both (A) and (R) are true and (R) is the explanation for (A).

(4) Both (A) and (R) are false.

Q.44 100 mL of 0.1 M HCl is taken in a beaker and to it 100 mL of 0.1 M NaOH is added in steps of 2 mL and the pH is continuously measured. Which of the following graphs correctly depicts the change in pH?

[JEE Main-2020 (September)]
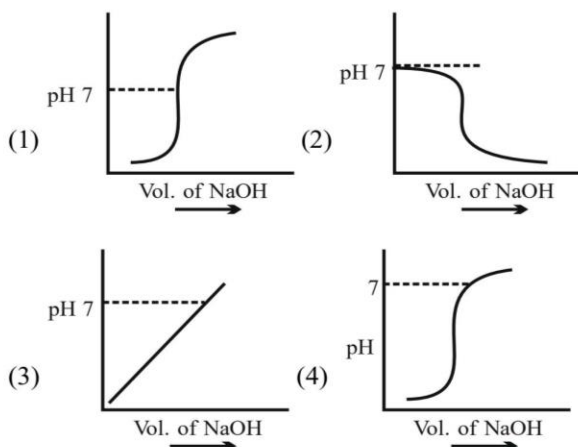
Q.45 An acidic buffer is obtained on mixing

[JEE Main-2020 (September)]

(1) 100 mL of 0.1 M HCl and 200 mL of 0.1 M NaCl

(2) 100 mL of 0.1 M HCl and 200 mL of 0.1 M CH_3COONa

(3) 100 mL of 0.1M CH_3COOH and 100 mL of 0.1 M NaOH

(4) 100 mL of 0.1 M CH_3COOH and 200 mL of 0.1 M NaOH

Q.46 A soft drink was bottled with a partial pressure of CO_2 of 3 bar over the liquid at room temperature. The partial pressure of CO_2 over the solution approaches a value of 30 bar when 44 g of CO_2 is dissolved in 1 kg of water at room temperature. The approximate pH of the soft drink is _____ $\times 10^{-1}$.

[JEE Main-2020 (September)]

(First dissociation constant of $H_2CO_3 = 4.0 \times 10^{-7}$; log 2 = 0.3; density of the soft drink = 1 g mL^{-1})

Q.47 If the solubility product of AB_2 is 3.20×10^{-11} M^3, then the solubility of AB_2 in pure water is _____ $\times 10^{-4}$ mol L^{-1}. [Assuming that neither kind of ion reacts with water] **[JEE Main-2020 (September)]**
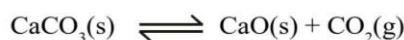
Q.48 Arrange the following solutions in the decreasing order of pOH

[JEE Main-2020 (September)]

(A) 0.01 M HCl

(B) 0.01 M NaOH

(C) 0.01 M CH_3COONa

(D) 0.01 M NaCl

(1) (B) > (C) > (D) > (A)

(2) (A) > (D) > (C) > (B)

(3) (A) > (C) > (D) > (B)

(4) (B) > (D) > (C) > (A)

JEE-ADVANCED
PREVIOUS YEAR'S
   CHEMICAL EQUILIBRIUM

Q.1 The thermal dissociation equilibrium of $CaCO_3(s)$ is studied under different conditions.

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$$

For this equilibrium, the correct statement(s) is (are) :

[JEE Advanced-2013]

(A) ΔH is dependent on T

(B) K is independent of the initial amount of $CaCO_3$

(C) K is dependent on the pressure of CO_2 at a given T

(D) ΔH is independent of the catalyst, if any

Paragraph for Question no. 2 to 3

Thermal decomposition of gaseous X_2 to gaseous X at 298 K takes place according to the following equation:

$$X_2(g) \rightleftharpoons 2X(g)$$

The standard reaction Gibbs energy, "$_rG^0$, of this reaction is positive. At the start of the reaction, there is one mole of X_2 and no. X. As the reaction proceeds, the number of moles of X formed is given by β. Thus, $\beta_{equilibrium}$ is the number of moles of X formed at equilibrium. The reaction is carried out at a constant total pressure of 2 bar. Consider the gases to behave ideally. (Given: $R = 0.083$ L bar K^{-1} mol^{-1})

[JEE Advanced-2016]

Q.2 The equilibrium constant K_P for this reaction at 298 K, in terms of $\beta_{equilibrium}$, is

(A) $\dfrac{8\beta_{equilibrium}}{2 - \beta_{equilibrium}}$

(B) $\dfrac{8\beta^2_{equilibrium}}{4 - \beta^2_{equilibrium}}$

(C) $\dfrac{4\beta^2_{equilibrium}}{2 - \beta_{equilibrium}}$

(D) $\dfrac{4\beta^2_{equilibrium}}{4 - \beta^2_{equilibrium}}$

Q.3 The INCORRECT statement among the following, for this reaction, is

(A) Decrease in the total pressure will return in formation of more moles of gaseous X

(B) At the start of the reaction, dissociation of gaseous X_2 takes place spontaneously

(C) $\beta_{equilibrium} = 0.7$

(D) $K_C < 1$

Q.4 For the following reaction, the equilibrium constant K_c at 298 K is 1.6×10^{17}.

$$Fe^{2+}(aq) + S^{2-}(aq) \rightleftharpoons FeS(s)$$
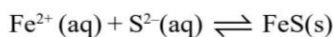
When equal volumes of 0.06 M Fe^{2+} (aq) and 0.2 M S^{2-} (aq) solutions are mixed, the equilibrium concentration of Fe^{2+}(aq) is found to be $Y \times 10^{-17}$ M. The value of Y is _____

[JEE Advanced - 2019]

Q.5 Consider the reaction $A \rightleftharpoons B$ at 1000 K. At time t', the temperature of the system was increased to 2000 K and the system was allowed to reach equilibrium. Throughout this experiment the partial pressure of **A** was maintained at 1 bar. Given below is the plot of the partial pressure of **B** with time. What is the ratio of the standard Gibbs energy of the reaction at 1000 K to that at 2000 K? **[JEE(Advanced) - 2020]**
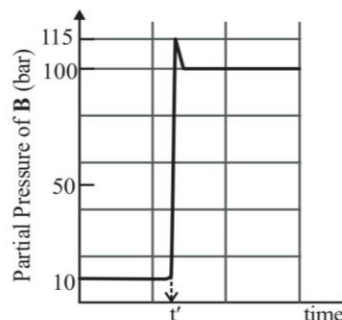
IONIC EQUILIBRIUM

Q.6 In 1 L saturated solution of AgCl [$K_{sp}(AgCl) = 1.6 \times 10^{-10}$], 0.1 mole of CuCl [$K_{sp}(CuCl) = 1.0 \times 10^{-6}$] is added. The resultant concentration of Ag^+ in the solution is 1.6×10^{-x}. The value of "x" is : **[JEE-2011]**

Q.7 The solubility of a salt of weak acid(AB) at pH 3 is $Y \times 10^{-3}$ mol L^{-1}. The value of Y is ___.
(Given that the value of solubility product of AB (K_{sp}) $= 2 \times 10^{-10}$ and the value of ionization constant of HB(K_a) $= 1 \times 10^{-8}$)

[JEE Advanced-2018]

Q.8 5.00 mL of 0.10 M oxalic acid solution taken in a conical flask is titrated against NaOH from a burette using phenolphthalein indicator. The volume of NaOH required for the appearance of permanent faint pink color is tabulated below for five experiments. What is the concentration, in molarity, of the NaOH solution ?

[JEE(Advanced) - 2020]

Exp. No.	Vol. of NaOH(mL)
1	12.5
2	10.5
3	9.0
4	9.0
5	9.0

Q.9 A solution of 0.1 M weak base (B) is titrated with 0.1 M of a strong acid (HA). The variation of pH of the solution with the volume of HA added is shown in the figure below. What is the pK_b of the base? The neutralization reaction is given by $B + HA \rightarrow BH^+ + A^-$.

[JEE Advanced - 2020]
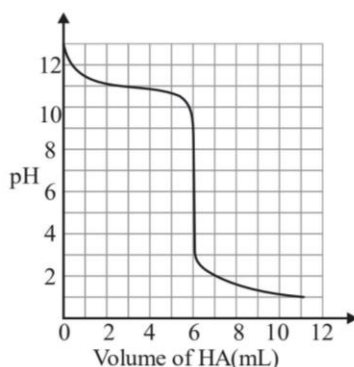
Q.10 An acidified solution of 0.05 M Zn^{2+} is saturated with 0.1 M H_2S. What is the minimum molar concentration (M) of H^+ required to prevent the precipitation of ZnS ? Use K_{sp} (ZnS) = 1.25×10^{-22} and Overall dissociation constant of H_2S, $K_{NET} = K_1 K_2$ = 1×10^{-21}

[JEE Advanced - 2020]

Answer Key

EXERCISE-I

Q.1 (3)	Q.2 (2)	Q.3 (4)	Q.4 (2)	Q.5 (4)	Q.6 (1)	Q.7 (4)	Q.8 (4)	Q.9 (3)	Q.10 (1)
Q.11 (2)	Q.12 (3)	Q.13 (1)	Q.14 (4)	Q.15 (2)	Q.16 (1)	Q.17 (2)	Q.18 (1)	Q.19 (3)	Q.20 (2)
Q.21 (1)	Q.22 (2)	Q.23 (3)	Q.24 (2)	Q.25 (3)	Q.26 (3)	Q.27 (1)	Q.28 (1)	Q.29 (1)	Q.30 (3)
Q.31 (4)	Q.32 (3)	Q.33 (4)	Q.34 (2)	Q.35 (3)	Q.36 (4)	Q.37 (2)	Q.38 (4)	Q.39 (3)	Q.40 (2)
Q.41 (3)	Q.42 (1)	Q.43 (1)	Q.44 (2)	Q.45 (2)	Q.46 (4)	Q.47 (2)	Q.48 (1)	Q.49 (3)	Q.50 (4)
Q.51 (4)	Q.52 (1)	Q.53 (4)	Q.54 (1)	Q.55 (4)	Q.56 (3)	Q.57 (1)	Q.58 (2)	Q.59 (4)	Q.60 (2)
Q.61 (3)	Q.62 (2)	Q.63 (3)	Q.64 (1)	Q.65 (4)	Q.66 (2)	Q.67 (3)	Q.68 (4)	Q.69 (2)	Q.70 (1)
Q.71 (2)	Q.72 (3)	Q.73 (3)	Q.74 (1)	Q.75 (4)	Q.76 (3)	Q.77 (4)	Q.78 (2)	Q.79 (1)	Q.80 (2)
Q.81 (3)	Q.82 (3)	Q.83 (2)	Q.84 (2)	Q.85 (2)	Q.86 (2)	Q.87 (2)	Q.88 (1)	Q.89 (1)	Q.90 (3)
Q.91 (2)	Q.92 (2)	Q.93 (3)	Q.94 (4)	Q.95 (2)	Q.96 (3)	Q.97 (4)	Q.98 (2)	Q.99 (2)	Q.100 (3)
Q.101 (3)	Q.102 (3)	Q.103 (3)	Q.104 (3)	Q.105 (1)	Q.106 (2)	Q.107 (1)	Q.108 (2)	Q.109 (3)	Q.110 (3)
Q.111 (4)	S.112 (1)	Q.113 (3)	Q.114 (2)	Q.115 (4)					

EXERCISE-II

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

EXERCISE-III

Q.1 (A,C)	Q.2 (A,C)	Q.3 (A,B,C)	Q.4 (C,D)	Q.5 (B,C)
Q.6 (C,D)	Q.7 (B,C)	Q.8 (C,D)	Q.9 (C,D)	Q.10 (C,D)
Q.11 (B,C,D)	Q.12 (C,D)	Q.13 (A,C)	Q.14 (A,B,C)	Q.15 (B, D)
Q.16 (A, B, C)	Q.17 (B, C)	Q.18 (B),(C),(D)	Q.19 (A, D)	Q.20 (A,B,C)
Q.21 (A,B,C)	Q.22 (A, C, D)	Q.23 (A, B)	Q.24 (A, C)	Q.25 (B, C)
Q.26 (B, C, D)	Q.27 (A, D)	Q.28 (A, B, C)	Q.29 (A,B)	Q.30 (A, D)
Q.31 (B, C)	Q.32 (C, D)	Q.33 (A,B)	Q.34 (B,D)	Q.35 (A, B)

Q.36 (B) Q.37 (A) Q.38 (B) Q.39 (D) Q.40 (C) Q.41 (A,B) Q.42 (C) Q.43 (C) Q.44 (B) Q.45 (D)

Q.46 (A) Q.47 (C) Q.48 (A) Q.49 (C) Q.50 (B)

Q.51 (A) q, s; (B) p ;(C) p ;(D) r   Q.52 A→p; B→q; C→s; D→r

Q.53 A–p,t ; B–q, r; C–q,s   Q.54 (A) → P,R,S; (B) → P,Q,R,S; (C) → P,Q,R,S ; (D) → Q

Q.55 A–S, B–S, C-Q

Q.56 [50] Q.57 [64] Q.58 [16] Q.59 [120] Q.60 [1] Q.61 [4.0%] Q.62 [10] Q.63 [9] Q.64 [3]

Q.65 [10,000]

EXERCISE-IV

JEE-MAIN
PREVIOUS YEAR'S

Q.1 (2)	Q.2 (4)	Q.3 (1)	Q.4 (4)	Q.5 (1)	Q.6 (3)	Q.7 (1)	Q.8 (3)	Q.9 (2)	Q.10 (3)
Q.11 (1)	Q.12 (4)	Q.13 (1)	Q.14 (2)	Q.15 (4)	Q.16 (4)	Q.17 (2)	Q.18 [16]	Q.19 (2)	Q.20 (1)
Q.21 (1)	Q.22 [3]	Q.23 [3]	Q.24 (1)	Q.25 (2)	Q.26 (1)	Q.27 (2)	Q.28 (1)	Q.29 (3)	Q.30 (2)
Q.31 (1)	Q.32 (4)	Q.33 (4)	Q.34 (4)	Q.35 (2)	Q.36 [10.60 to 10.60]		Q.37 [5.22 to 5.24]		Q.38 (2)
Q.39 (3)	Q.40 (2)	Q.41 (2)	Q.42 [4]	Q.43 (3)	Q.44 (1)	Q.45 (2)	Q.46 [37]	Q.47 [02]	Q.48 (2)

JEE-ADVANCED
PREVIOUS YEAR'S

Q.1 (A,B,D) Q.2 (B) Q.3 (C) Q.4 [8.92 or 8.93] Q.5 [0.25] Q.6 [7] Q.7 [4.47] Q.8 [0.11]

Q.9 [2.30 TO 3.00] Q.10 [0.20]

IIT - NEET - Chemistry

EXERCISE (Solution)

EXERCISE-I

Q.1 (3)

When rate of forward reaction is equal to rate of backward reaction the reaction is said to be in equilibrium.

Q.2 (2)

At equilibrium, the rate of forward & backward reaction become equal.

Q.3 (4) $[HI] = \dfrac{64gm}{128 \times 2\,litre} = 0.25$

Q.4 (2)

Q.5 (4)

Q.6 (1)

As we increase the concentration of substance, then speed of the reaction increases

Q.7 (4)

Equilibrium constant for the reaction

$3A + 2B \rightleftharpoons C$ is $K = \dfrac{[C]}{[A]^3[B]^2}$

Q.8 (4)

Suppose 1 mole of A and B each taken then 0.8 mole/litre of C and D each formed remaining concentration of A and B will be (1 - 0.8) = 0.2 mole/litre each.

$Kc = \dfrac{[C][D]}{[A][B]} = \dfrac{0.8 \times 0.8}{0.2 \times 0.2} = 16.0$

Q.9 (3)

$$A + B \rightleftharpoons C + D$$

Initial conc.   4,   4
             0   0

After T time conc.   (4-2)   (4-2)
                2   2

Equilibrium constant $= \dfrac{[C][D]}{[A][B]} = \dfrac{2 \times 2}{2 \times 2} = 1$

Q.10 (1)

For reaction $A + 2B \rightleftharpoons C$

$K = \dfrac{[C]}{[A][B]^2} = \dfrac{0.216}{0.06 \times 0.12 \times 0.12} = 250$

Q.11 (2)

$A + 2B \rightleftharpoons C + 3D$

$K = \dfrac{[pC][pD]^3}{[pA][pB]^2} = \dfrac{0.30 \times 0.50 \times 0.50 \times 0.50}{0.20 \times 0.10 \times 0.10} = 18.75$

Q.12 (3)

Q.13 (1)

$$PCl_5 \rightleftharpoons PCl_3 + Cl_2$$
$\quad 2 \qquad\qquad 0 \qquad 0$
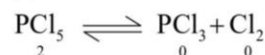
$\dfrac{2 \times 60}{100} \qquad \dfrac{2 \times 40}{100} \quad \dfrac{2 \times 40}{100}$

Volume of container = 2 litre.

$K_c = \dfrac{\dfrac{2 \times 40}{100 \times 2} \times \dfrac{2 \times 40}{100 \times 2}}{\dfrac{2 \times 60}{100 \times 2}} = 0.266$

Q.14 (4)

Unit of $K_p = (atm)^{\Delta n}$

Unit of $K_c = (mole/litre)^{\Delta n}$

$= [mole/litre]^0 = 0$

Q.15 (2)

For $A + B \rightleftharpoons C + D$

$K = \dfrac{[C][D]}{[A][B]} = \dfrac{0.4 \times 1}{0.5 \times 0.8} = 1$

Q.16 (1)

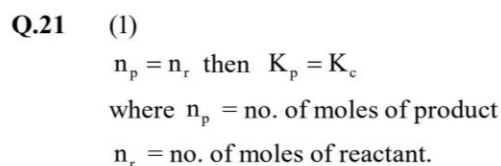$K_p = \dfrac{[P_{CO}]^2[P_{O_2}]}{[P_{CO_2}]^2} = \dfrac{[0.4]^2 \times [0.2]}{[0.6]^2} = 0.0888$

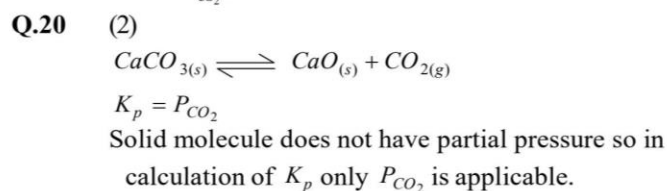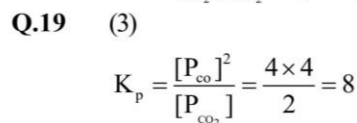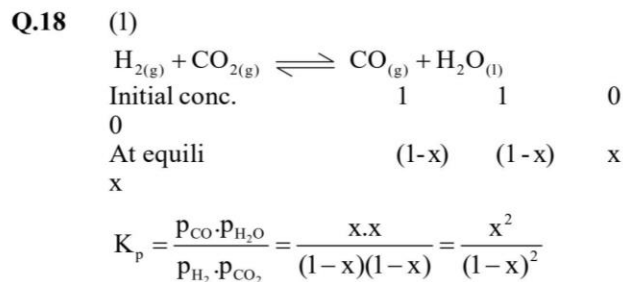**Q.17** (2)

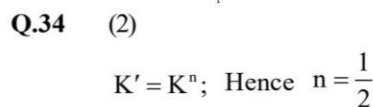Given, $CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2(g) \uparrow$

$C(s) + CO_2(g) \rightleftharpoons 2CO(g)$

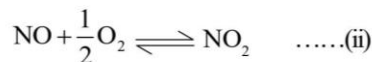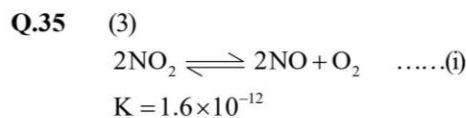$Kp_2 = \dfrac{[pCO]^2}{[pCO_2]}$; $pCO = \sqrt{[Kp_1 \times Kp_2]}$

$pCO = \sqrt{[8 \times 10^{-2} \times 2]} = \sqrt{16 \times 10^{-2}} = 4 \times 10^{-1} = 0.4$

Q.18 (1)

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

Initial conc.   1   1   0   0

At equili $(1-x)$ $(1-x)$ x   x

$$K_p = \frac{p_{CO} \cdot p_{H_2O}}{p_{H_2} \cdot p_{CO_2}} = \frac{x \cdot x}{(1-x)(1-x)} = \frac{x^2}{(1-x)^2}$$

Q.19 (3)

$$K_p = \frac{[P_{co}]^2}{[P_{co_2}]} = \frac{4 \times 4}{2} = 8$$

Q.20 (2)

$$CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$$

$$K_p = P_{CO_2}$$

Solid molecule does not have partial pressure so in calculation of K_p only P_{CO_2} is applicable.

Q.21 (1)

$n_p = n_r$ then $K_p = K_c$

where n_p = no. of moles of product

n_r = no. of moles of reactant.

Q.22 (2)

Q.23 (3)

Q.24 (2)

$K_p = K_c (RT)^{\Delta n}$ When $\Delta n = 2 - (2+1) = -1$ i.e.

negative = $K_p < K_c$

Q.25 (3)

$K_p = K_c (RT)^{\Delta n}$; $\Delta n = 2 - 2 = 0$

Q.26 (3)

$\Delta n = 2 - 1 = 1$

$K_p = K_c (RT)$

Q.27 (1)

$k_p = k_c (RT)^{\Delta n}$

$\Delta n = 3 - 2 = 1$; $k_p > k_c$

Q.28 (1)

$K_p = K_c (RT)^{\Delta n}$; $\Delta n = 2 - 4 = -2$

$K_p = 6 \times 10^{-2} \times (0.0812 \times 773)^{-2}$

$$K_p = \frac{6 \times 10^{-2}}{(0.0812 \times 773)^2} = 1.5 \times 10^{-5}$$

Q.29 (1)

Those reaction which have more value of K proceeds towards completion

Q.30 (3)

For this reaction there is no change in equilibrium constant by change of volume.

Q.31 (4)

K_f is a characteristic constant for the given reaction

Q.32 (3)

$$K_1 = \frac{[SO_3]}{[SO_2][O_2]^{1/2}} \text{ and } K_2 = \frac{[SO_2]^2[O_2]}{[SO_3]^2}; \ K_2 = \frac{1}{K_1^2}$$

Q.33 (4)

K_{c_1} for $H_2 + I_2 \rightleftharpoons 2HI$ is 50

K_{c_2} for $2HI \rightleftharpoons H_2 + I_2$

$$K_{c_2} = \frac{1}{K_{c_1}} = \frac{1}{50} = 0.02$$

Q.34 (2)

$K' = K^n$; Hence $n = \frac{1}{2}$

$\therefore K' = K^{1/2} = \sqrt{K}$

Q.35 (3)

$2NO_2 \rightleftharpoons 2NO + O_2$ ......(i)

$K = 1.6 \times 10^{-12}$

$NO + \frac{1}{2}O_2 \rightleftharpoons NO_2$ ......(ii)

Reaction (ii) is half of reaction (i)

$$K = \frac{[NO]^2[O_2]}{[NO_2]^2} \qquad ......(i)$$

$$K' = \frac{[NO_2]}{[NO][O_2]^{1/2}} \qquad ......(ii)$$

On multiplying (i) and (ii)

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

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

$$K \times K' = \frac{1}{K'}; \ K = \frac{1}{K'^2}; \ K' = \frac{1}{\sqrt{K}}$$

Q.36 (4)

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

K_2 for $NH_3 \rightleftharpoons \frac{1}{2}N_2 + \frac{3}{2}H_2$
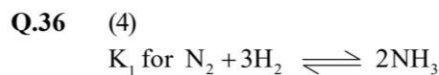
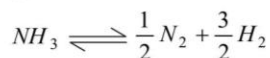$$K_1 \times K_2 = \frac{[NH_3]^2}{[N_2][H_2]^3} \times \frac{[N_2]^{1/2}[H_2]^{3/2}}{[NH_3]}$$

$$K_1 \times K_2 = \frac{1}{K_2}; \ K_2 = \frac{1}{\sqrt{K_1}}$$

Q.37 (2)

$$2.303 \log \frac{K_2}{K_1} = \frac{\Delta H}{R} \frac{[T_2 - T_1]}{T_1 \times T_2}$$

$\Delta H = $ +ve for the reaction

Q.38 (4)

$$NH_3 \rightleftharpoons \frac{1}{2} N_2 + \frac{3}{2} H_2$$

$$K_c = \frac{[N_2]^{1/2}[H_2]^{3/2}}{NH_3} \quad \text{and} \quad \frac{1}{2} N_2 + \frac{3}{2} H_2 \rightleftharpoons NH_3$$

$$K_c = \frac{[NH_3]}{[N_2]^{1/2}[H_2]^{3/2}}$$

So for dissociation $= \dfrac{1}{K_c}$

Q.39 (3)

$$K_1 = \frac{[H_2S]}{[H_2][S_2]^{1/2}} \; ; \; K_2 = \frac{[HBr]^2}{[H_2][Br_2]}$$

$$K_3 = \frac{[HBr]^2 \times [S_2]^{1/2}}{[Br_2] \times [H_2S]} \; ; \; \frac{K_2}{K_1} = K_3$$

Q.40 (2)

Q.41 (3)

$$K_c = \frac{[NO_2]^2}{[N_2O_4]} = \frac{4 \times (0.05)^2}{0.05} = 4 \times 0.05 = 0.2$$

Q.42 (1)

$$\frac{22}{100} \times 3.2 = 0.704$$

at equil. moles of HI $= 3.2 - 0.704 = 2.496$

Q.43 (1)

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$
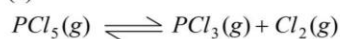
For this reaction $\Delta n = 2 - 1 = 1$

Value of Δn is positive so the dissociation of PCl_5 take forward by decrease in pressure & by increase in pressure the dissociation of PCl_5 decrease.

Q.44 (2)

$$\frac{\text{Normal molecular weight}}{\text{experiment al molecular wt.}} = 1 + \alpha$$

$$NH_4Cl \rightleftharpoons NH_3 + HCl$$
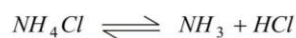
$\because \alpha = 1 \; \therefore$ Experimental Molecular wt $= \dfrac{\text{nor.mol.wt.}}{2}$

Q.45 (2)

$$K_c = \frac{[PCl_3][Cl_2]}{[PCl_5]} = \frac{\left[\dfrac{20}{100}\right] \times \left[\dfrac{20}{100}\right]}{\left[\dfrac{80}{100}\right]}$$

$$= \frac{0.2 \times 0.2}{0.8} = \frac{0.04}{0.8} = 0.05$$

Q.46 (4)

$$NH_4HS \rightleftharpoons NH_{3(g)} + H_2S_{(g)}$$

$$\begin{array}{ccc} a & & 0.5atm \\ a-x & 0.5+x & x \end{array}$$
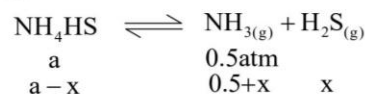
Total pressure $= 0.5 + 2x = 0.84$

i.e., $x = 0.17$

$K_p = P_{NH_3} . P_{H_2S} = 0.1139 = (0.67).(0.17) = 0.1139$

Q.47 (2)

Q.48 (1)

For this reaction Δn is negative & ΔH is positive so it take forward by decrease in temperature.

Q.49 (3)

According to Le-chatelier principle when concentration of reactant increases, the equilibrium shift in favour of forward reaction.

Q.50 (4)

We know that

P become $\dfrac{1}{2}$P & V bcome 2V so,

$$\frac{1}{2}P \times 2V = PV = nRT$$

So there is no effect in equation

Q.51 (4)

Equilibrium constant depends upon temperature

Q.52 (1)

According to Le-Chatelier principle exothermic reaction is forwarded by low temperature, in forward direction number of moles is less, hence pressure is high.

Q.53 (4)

Equilibrium constant changes with temperature, pressure and the concentration of either reactant or product.

Q.54 (1)

$$N_2 + O_2 \rightleftharpoons 2NO; Q \; cal$$

The above reaction is endothermic so for higher production of NO, and the temperature should be high.

Q.55 (4)

According to Le-chatelier's principle.

Q.56 (3)

At low pressure, reaction proceeds where volume is increasing. This is the favourable condition for the reaction. $PCl_5 \rightleftharpoons PCl_3 + Cl_2$.
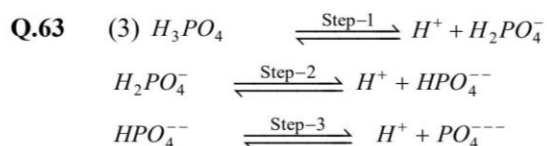
Q.57 (1)

Q.58 (2)

Q.59 (4) $HClO_4 + H_2O \rightleftharpoons H_3O^+ + ClO_4^-$

Q.60 (2)

Those substance accept the proton are called Bronsted base and which is donate the proton are called Bronsted acid.

$HCO_3^- + H^+ \rightleftharpoons H_2CO_3$ Bronsted base.

$HCO_3^- \rightleftharpoons H^+ + CO_3^{--}$ Bronsted acid.
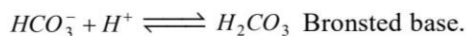
Q.61 (3)

Because it is a electron pair acceptor it's central atom have a vacant d-orbital

Q.62 (2)

The basic character of hydride decreases down the group.

Q.63 (3) $H_3PO_4 \xrightarrow{\text{Step-1}} H^+ + H_2PO_4^-$

$H_2PO_4^- \xrightarrow{\text{Step-2}} H^+ + HPO_4^{--}$

$HPO_4^{--} \xrightarrow{\text{Step-3}} H^+ + PO_4^{---}$

Q.64 (1)

On increasing oxidation number Acidic strength increases.

Q.65 (4)

Q.66 (2)

According to Bronsted principle HNO_3 is acid they give H^+ in aqueous solution and form NO_3^-.

Q.67 (3)

Q.68 (4)

Q.69 (2)

For pure water $[H^+] = [OH^-]$, $\therefore K_w = 10^{-12}$ s

Q.70 (1)

Because pure water has a 7 pH.

Q.71 (2)

$CH_3COOH + HF \rightleftharpoons CH_3COOH_2^+ + F^-$. HF gives H^+ to the CH_3COOH. So it is a conjugate base of HF

Q.72 (3) $H_2SO_4 \rightleftharpoons H^+ + HSO_4^-$.

Q.73 (3) $\underset{\text{Conjugate acid}}{H_2PO_4^-} \rightleftharpoons H^+ + HPO_4^{2-}$ action.

Q.74 (1)

Conjugate acid is obtained from the base by gain of H^+.

Q.75 (4)

HCl is a strong acid its conjugate base means Cl^- is a weak base

Q.76 (3) $pH = 4$ means; $[H^+] = 10^{-4}$ mol

Q.77 (4)

$10^{-3} N$ KOH will give $[OH^-] = 10^{-2}$ M

$pOH = 2$

$\because pH + pOH = 14$, $pH = 14 - 2 = 12$

Q.78 (2)

Q.79 (1) $[OH^-] = 10^{-2}$ M; $pOH = 2$

$pH + pOH = 14$; $pH = 14 - pOH$

$pH = 14 - 2 = 12$

Q.80 (2)

$\dfrac{N}{100} = 0.01$ N HCl ; $[H^+] = 10^{-2}$ M ; $pH = 2$

$[OH] = 10^{-2}$ M for NaOH

$pH + pOH = 14$; $pH = 14 - 2$; $pH = 12$

Q.81 (3)

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

$HCl \rightleftharpoons [H^+][Cl^-]$

Total $[H^+] = [H^+]_{H_2O} + [H^+]_{HCl} = 10^{-7} + 10^{-8}$

$= 10^{-7}[1 + 10^{-1}]$

$[H^+] = 10^{-7} \times \dfrac{11}{10}$

$pH = -\log[H^+] = -\log\left(10^{-7} + \dfrac{11}{10}\right)$; $pH = 6.958$

Q.82 (3) H_2SO_4 ionized in two step

Q.83 (2)

$[H^+] = 2 \times 10^{-2}$ M

$\because pH = -\log[2 \times 10^{-2}]$;

$pH = 1.7$ i.e. in between 1 and 2.

Q.84 (2)

Q.85 (2)

10^{-10} M $HCl = 10^{-10}$ M$[H^+]$. But pH $\neq 10$ because solution is acidic. This is because H^+ from $H_2O(10^{-7} M)$ cannot be neglected.

Total $[H^+] = 10^{-7} + 10^{-10}$

$= 10^{-7} + (1 + 10^{-3}) = 10^{-7}(1.001)$

That is why $pH = 7$ (slightly less than 7)

Q.86 (2)
Because the degree of dissociation is inversely proportional to the concentration of the electrolyte

Q.87 (2)
Electrolytes are those substances which dissociates in water to give ions.

Q.88 (1)

$$K = \frac{\alpha^2 C}{1-\alpha}; \alpha = \frac{0.01}{100} \approx 1 \therefore K = \alpha^2 C = \left[\frac{0.01}{100}\right]^2 \times 1$$

$$= 1 \times 10^{-8}.$$

Q.89 (1) $NaCl$, being a salt, is a strong electrolyte.

Q.90 (3)
According to the Ostwald's dilution formula $\alpha^2 = \frac{K(1-\alpha)}{C}$. But for weak electrolytes α is very small. So that $(1-\alpha)$ can be neglected. So that

$$\alpha = \sqrt{\frac{K_a}{C}}.$$

Q.91 (2) $\alpha \propto$ dilution of solution
Q.92 (2) Mathematical form of Ostwald's dilution law.

Q.93 (3)
Q.94 (4)

$$[H^+] = \alpha.C = \frac{2}{100} \times .02 ; \quad [H^+] = 4 \times 10^{-4} M$$

$$pH = -\log[H^+] = 4 - \log 4 ; \, pH = 3.3979$$

Q.95 (2)

$$pH = 3, [H^+] = 10^{-3} M \qquad \because [H^+] = \sqrt{K \times c}$$

$$[10^{-3}]^2 = K \times c ; \frac{[10^{-6}]}{0.1} = K = 10^{-5}$$

Q.96 (3)
For NH_4OH.

$$[OH^-] = C.\alpha ; \, C = \frac{1}{10} M, \, \alpha = 0.2$$

$$[OH^-] = \frac{1}{10} \times 0.2 = 2 \times 10^{-2} M$$

$$pOH = -\log[OH^-] = \log[2 \times 10^{-2}] ; \, pOH = 1.7$$

$$pH = 14 - pOH = 14 - 1.7 = 12.30.$$

Q.97 (4) Salt of a strong base with a weak acid
Q.98 (2)
NH_4CN is a salt of weak acid and weak base and thus for it
Q.99 (2)
Alkaline, $CH_3COONa + H_2O$

$$\rightleftharpoons \underset{\text{Weak acid}}{CH_3COOH} + \underset{\text{Strong base}}{NaOH}$$

Q.100 (3) Because it is a strong base.

Q.101 (3) Fe^{3+} ions are hydrolysed to develop acidic nature

Q.102 (3) $K_h = \frac{K_w}{K_a \times K_b}$

Q.103 (3)
0.001 M of $NaOH$ means $[OH^-] = .001$

$$= 10^{-3} M \Rightarrow pOH = 3$$

$$pH + pOH = 14 \Rightarrow pH = 14 - 3 = 11$$

Q.104 (3)

$$pK_a = -\log K_u, pK_b = -\log K_b$$

$$pH = -\frac{1}{2}[\log K_a + \log K_w - \log K_b]$$

$$= -\frac{1}{2}[-5 + \log(1 \times 10^{-14}) - (-5)]$$

$$= -\frac{1}{2}[-5 - 14 + 5] = -\frac{1}{2}(-14) = 7$$

Q.105 (1) $MgCl_2 + 2H_2O \,ì!\, Mg(OH)_2 + 2HCl$

Q.106 (2) It contains replacable H atom.

Q.107 (1)
An acid buffer solution consists of solution of weak acid with strong base of its salt.

Q.108 (2)
[Salt]= 0.1 M, [Acid]= 0.1 M

$$K_a = 1.8 \times 10^{-5} ; \, pH = -\log K_a + \log\frac{[Salt]}{[Acid]}$$

$$= -\log 1.8 \times 10^{-5} + \log\frac{0.1}{0.1} = -\log 1.8 \times 10^{-5}$$

$$pH = 4.7.$$

Q.109 (3) CH_3COONH_4 is a simple buffer and called salt of weak acid.

Q.110 (3) A strong acid is not used to make a buffer

Q.111 (4) NH_4OH is a weak acid and NH_4Cl is a strong base salt.

Q.112 (1)

$$pH = pK_a + \log\frac{[Salt]}{[Acid]} = -\log 2 \times 10^{-5} + \log\frac{10 \times 1}{50 \times 2} = 4.$$

Q.113 (3)

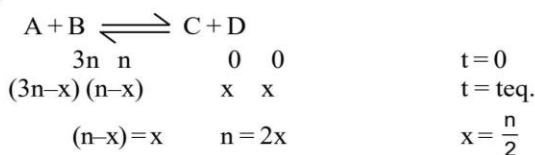$$BaSO_4 \rightleftharpoons \underset{\underset{0.01}{(S)}}{Ba^{++}} + \underset{\underset{5}{(S)}}{SO_4^{--}}$$

$K_{sp} = S^2 = S \times S = 0.01 \times S$

$S_{(SO_4^{2-})} = \dfrac{K_{sp}}{S_{(Ba^{++})}} = \dfrac{1 \times 10^{-9}}{0.01} = 10^{-7}$ mole/litre

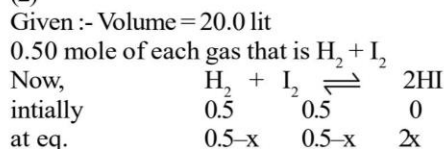**Q.114** (2) $CaF_2 \rightleftharpoons \underset{(S)}{Ca^{++}} + \underset{(2S)^2}{2F^-}$; $K_{sp} = 4S^3$

Q.115 (4) K_{sp} for $CaF_2 = 4s^3 = 4 \times [2 \times 10^{-4}]^3 = 3.2 \times 10^{-11}$.

EXERCISE-II

Q.1 (1)

$$A + B \rightleftharpoons C + D$$

3n	n	0	0	t = 0
(3n–x)	(n–x)	x	x	t = teq.
(n–x) = x		n = 2x		$x = \dfrac{n}{2}$

Q.2 (2)

Given :- Volume = 20.0 lit
0.50 mole of each gas that is $H_2 + I_2$

Now, $\quad H_2 \ + \ I_2 \rightleftharpoons 2HI$
intially $\qquad$ 0.5 $\quad$ 0.5 $\qquad$ 0
at eq. $\qquad$ 0.5–x $\quad$ 0.5–x $\quad$ 2x
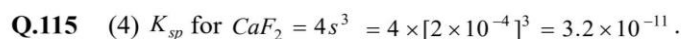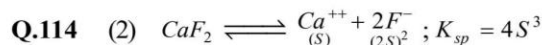
$K_{eq} = \dfrac{[HI]^2}{[H_2][I_2]}$

$49 = \dfrac{(2x)^2}{(0.5-x)^2}$ $\qquad$ (as $K_{eq} = 49$)

$7 = \dfrac{2x}{0.5-x}$

$2x = 3.5 - 7x$

$9x = 3.5$

$x = 0.39$

conc. of $[HI] = \dfrac{2x}{20} - \dfrac{x}{10} \Rightarrow \dfrac{.39}{10} = 0.039$

Q.3 (4)

$A \rightleftharpoons B$
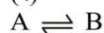
The rate transformation of A to B just equal to rate of transformation of B to A in the system.

Q.4 (1) The rate of reaction directly propotional to molarities of the reactant.

Q.5 (1)

Given : Equilibrium constant, $K_C = 2.5$

We know :

$\dfrac{K_f}{K_b} = 2.5$

$K_f = 2.5 \times 3.2 \times 10^{-2} = 8 \times 10^{-2}$

Q.6 (2)

$C_2H_5OH(\ell) + CH_3COOH(\ell) \rightleftharpoons CH_3COOC_2H_5(\ell) + H_2O(\ell)$.
a $\qquad\qquad$ a $\qquad\qquad\qquad$ 0 $\qquad\qquad$ 0
a 0.33a $\qquad$ a – 0.33a $\qquad$ 0.33a $\qquad$ 0.33a

$K_C = \dfrac{(0.33a) \times (0.33a)}{(0.67a) \times (0.67a)} = K_C = 1/4$.

Q.7 (1)

Given :- $N_2O_4 \rightleftharpoons 2NO_2$
$\qquad\quad$ (g) $\qquad\qquad$ (g)
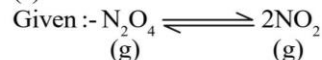
conc. of $N_2O_4 = 4.8 \times 10^{-2}$ mol/lit
$NO_2 = 1.2 \times 10^{-2}$ mol/lit

$\therefore \quad K_C = \dfrac{(1.2 \times 10^{-2})^2}{(4.8 \times 10^{-2})} = 3 \times 10^{-3}$

Q.8 (2)

Given : $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$
$\qquad\qquad\qquad\quad K_C = 4 \times 10^{-4}$

Now, $\quad$ No (g) $\rightleftharpoons \dfrac{1}{2}N_2(g) + \dfrac{1}{2}O_2(g)$
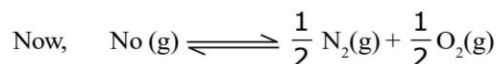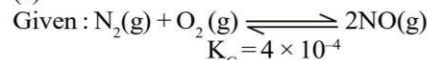
$\qquad\qquad K_C' = ?$

$K_C' = \dfrac{1}{[K_C]^{1/2}} \Rightarrow \dfrac{1}{(4 \times 10^{-4})^{1/2}}$

$\Rightarrow \dfrac{1}{2 \times 10^{-2}} \Rightarrow 50$

Q.9 (2)

Given :
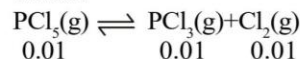
$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$
0.01 $\qquad\quad$ 0.01 $\quad$ 0.01

$K_{C_1} = \dfrac{[PCl_3] \times [Cl_2]}{[0.01]} \Rightarrow \dfrac{0.01 \times 0.01}{0.01} = 0.01$
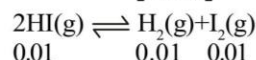
$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$
0.01 $\qquad\quad$ 0.01 $\quad$ 0.01

$K_{C_2} = \dfrac{0.01 \times 0.01}{(0.01)^2} = 1$
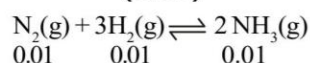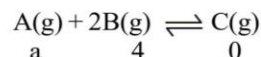
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
0.01 $\qquad$ 0.01 $\qquad\quad$ 0.01

$K_{C_3} = \dfrac{(0.01)^2}{(0.01)(0.01)^3} = \dfrac{1}{10^{-4}} = 10^{-4}$

Extent of reaction K_C (iii) > (ii) > (i)

Q.10 (3)

Given :- reaction

$$A(g) + 2B(g) \rightleftharpoons C(g)$$
$\qquad$ a $\qquad\quad$ 4 $\qquad$ 0

(at equill.) $\qquad$ a–x $\quad$ 4–2x $\quad$ x

as x = 1

A(g) = a – 1, $\qquad\qquad$ B(g)=2, C(g)=1

$$[A] = \frac{a-1}{5} \qquad [B] = \frac{2}{5}, [C] = \frac{1}{5}$$

$$K_C = \frac{(1/5)}{\left(\frac{2}{5}\right)^2 \left(\frac{a-1}{5}\right)} \quad K_C = \frac{25}{4(a-1)} \qquad ....(1)$$

as $K_C = 0.25$ ....(2)

from (1) & (2)

$$.25 = \frac{25}{4(a-1)}$$

$$\Rightarrow 4(a-1) = 100$$

$$a - 1 = 25$$

$$\Rightarrow a = 26$$

Q.11 (2)

Given 1 mole N_2, 3 mole H_2

total pressure = 4 atm

reaction $\qquad N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

initially $\qquad\qquad 1 \qquad\quad 3 \qquad\qquad 3$

at equilibrium $\quad 1-x \quad\ 3-3x \qquad\ 2x$

$P_{total} = 1 - x + 3 - 3x + 2x$

$\qquad\qquad = 4 - 2x$ ....(1)

an given in question

P_{total} fall to 3 atm

$\therefore \qquad\quad P_{total} = 3$ ....(2)

from (1) & (2)

$$3 = 4 - 2x \Rightarrow \boxed{x = \frac{1}{2}}$$

$$P_{N_2} = \frac{1}{2} \; ; \; P_{H_2} = 3 - \frac{3}{2} \; ; \; P_{NH_3} \text{ (eq.)} = 2 \times \frac{1}{2}$$

$$\Rightarrow \frac{3}{2} \qquad\qquad\qquad\qquad \Rightarrow 1$$

$$K_p = \frac{(P_{NH_3})^2}{(P_{N_2})(P_{H_2})^3} = \frac{(1)^2}{\frac{1}{2} \times \left(\frac{3}{2}\right)^3}$$

$$\Rightarrow \frac{1}{0.5 \times (1.5)^3}$$

K_p for dissociation of $NH_3 \Rightarrow (0.5) \times (1.5)^3$

Q.12 (1)

$2H_2O(g) + 2Cl_2(g) \rightleftharpoons 2HCl(g) + O_2(g)$

$K_p = 0.03 \qquad\qquad\qquad T = 477°C = 700 K$

$K_p = K_C(RT)^1$

$$K_C = \frac{K_P}{RT} = \left[\frac{0.03}{0.082 \times 700}\right]$$

$K_C = 5.23 \times 10^{-4}$

Q.13 (2)

Using $\qquad\qquad\qquad K_P = K_C(RT)^{\Delta n_g}$

so, $\qquad \log\frac{K_P}{K_C} = \Delta n_g \log RT$

so, $\qquad \Delta n_g = -1$.

Q.14 (4)

Given :- $N_2O_4(g) \rightleftharpoons 2NO_2(g)$

$K_p = K_C$ ......(1)

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

$\Delta n_g = 2 - 1$

$\Rightarrow \qquad 1$

$K_p = K_C \times RT$

$RT = 1$

$$T = \frac{1}{R}$$

$$\Rightarrow \frac{1}{0.082} \quad \Rightarrow 12.19 K$$

$T = 12.19 K$

Q.15 (3)

Given :- $CO(g) + \frac{1}{2}O_2(g) \rightleftharpoons CO_2(g)$

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

$$\Delta n_g = -\frac{1}{2}$$

as we know

$$K_p = K_C(RT)^{\Delta n_g} \Rightarrow \frac{K_p}{K_C} = (RT)^{-1/2}$$

Q.16 (2)

Given :- Reaction as

$\qquad\qquad H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$

Here $\qquad K_P = K_C$

initally $\quad 0.25 \qquad 0.25 \qquad\quad 0 \qquad\qquad 0$

at eq. $\quad 0.25-x \quad 0.25x \qquad\ x \qquad\qquad x$

$$K_C = \frac{[CO][H_2O]}{[H_2][CO_2]} \Rightarrow \frac{x^2}{(0.25-x)^2}$$

$$\Rightarrow 0.16 - \frac{x^2}{(0.25-x)^2} \quad [\text{as } K_P = K_C = 0.16]$$

$$\frac{x^2}{(0.25-x)} = 0.4$$

$x = 0.1 - 0.4x$

$$x = \frac{0.1}{1.4} = \frac{1}{14}$$

% mole of CO $= \frac{(1/14)}{\text{total mole}} \times 100$

total mole = 0.5 mole

% mole of CO $= \frac{(1/14)}{0.5} \times 100$

$= 14.28\%$

Q.17 (3)

Given: $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ $K_p = 0.5$

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

now,

$\Delta n_g = 2 - 2 = 0$

$\therefore K_p = K_C$

$K_C = 50$

Q.18 (1)

PCl_5 dissociation a closed container
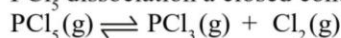
$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$
$$\begin{array}{ccc} 1 & 0 & 0 \\ 1-\alpha & \alpha & \alpha \end{array}$$

Total mole $= 1 - \alpha + \alpha + \alpha$

$\Rightarrow 1 + \alpha$

K_{PCl_3} (mole fraction) $= \dfrac{\alpha}{1+\alpha}$

$\therefore$ (partial pressure) $P_{PCl_3} = \left[\dfrac{\alpha}{1+\alpha}\right]^P$

Q.19 (1)

$$N_2O_4 \rightleftharpoons 2NO_2 \qquad M_{mix} = \dfrac{(1-\alpha)\,92 + 2\alpha \times 46}{1+\alpha}$$
$$\begin{array}{cc} 1-\alpha & 2\alpha \end{array}$$

$M_{mix} = \dfrac{92}{1+\alpha}$

$\dfrac{D}{d} = \dfrac{46}{46/(1+\alpha)} = (1+\alpha).$ Therefore, (1) option is correct.

Q.20 (2)

$\alpha = \left[\dfrac{D-d}{d}\right]; \; \alpha = \left[\dfrac{D}{d} - 1\right]; \; \left(\dfrac{D}{d}\right) = \alpha + 1.$

$\alpha = \dfrac{D-d}{(n-1)d}; \; \alpha = \dfrac{D-d}{d}; \quad \alpha = \left(\dfrac{D}{d}\right) - 1.$

The point at which $\alpha = 0$.
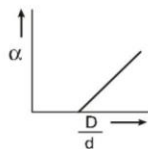
$\left[\dfrac{D}{d} - 1\right] = 0 \,; So, \left(\dfrac{D}{d}\right) = 1.$

Q.21 (4)

Given - Reaction :

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$
$$\begin{array}{ccc} 1 & 0 & 0 \end{array}$$

$$\begin{array}{ccc} 1-\alpha & \dfrac{\alpha}{\alpha} & \dfrac{\alpha}{\alpha} \end{array} \quad \text{(where a is degree}$$
$$\begin{array}{ccc} C(1-\alpha) & \dfrac{C\alpha}{2} & \dfrac{C\alpha}{2} \end{array} \quad \text{of dissociation)}$$

as $\qquad K_C = K_p = \dfrac{\alpha^2}{4(1-\alpha)^2}$

$\sqrt{K_p} = \dfrac{\alpha}{2(1-\alpha)}$

$2\sqrt{K_p} = \dfrac{\alpha}{1-\alpha}$

$\dfrac{1-\alpha}{\alpha} = \dfrac{1}{2\sqrt{K_p}} \;\Rightarrow\; \dfrac{1}{\alpha} - 1 = \dfrac{1}{2\sqrt{K_p}}$

$\dfrac{1}{\alpha} = 1 + \dfrac{1}{2\sqrt{K_p}}$

$\dfrac{1}{\alpha} = \dfrac{2\sqrt{K_p}+1}{2\sqrt{K_p}} \;\Rightarrow\; \alpha = \dfrac{2\sqrt{K_p}}{2\sqrt{K_p}+1}$

Q.22 (1)

$(VD)_{mix} = \dfrac{M_{mix}}{2} = \dfrac{M}{2(1+\alpha)}$

so, as α increases $(VD)_{mix}$ decreases.

Q.23 (1)

Given - V.D of $N_2O_4 = 30$

$$N_2O_4 \rightleftharpoons 2NO_2$$
$$\begin{array}{cc} 1 & 0 \\ 1-\alpha & 22 \end{array}$$
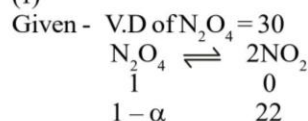
Total mole $= 1 + 2\alpha - \alpha \;\Rightarrow\; 1 + \alpha$

Mass conservation

wt. of N_2O_4 at $t = 0$ = wt. of mixture.

$1 \times (92) = (1+\alpha)\, 2 \times 30$

$\Rightarrow \dfrac{92}{60} = 1 + \alpha$

$\alpha = \dfrac{32}{60} \;\Rightarrow\; \dfrac{8}{15}$

$\alpha\% = \dfrac{8}{15} \times 100 = 53.3\%$

Q.24 (1)

Given:

$$A_{(g)} + B_{(g)} \rightleftharpoons C_{(g)} + D_{(g)}$$
$$\begin{array}{cccc} 1 & 1 & 0 & 0 \\ 1-\alpha & 1-\alpha & \alpha & \alpha \end{array}$$
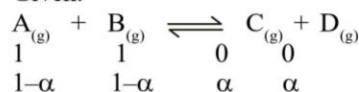
$K = \dfrac{[C][D]}{[B][A]}$

$K = \dfrac{\alpha^2}{(1-\alpha)^2}$

$$\sqrt{K} = \frac{\alpha}{1-\alpha}$$
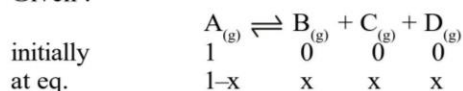
$$\frac{1-\alpha}{\alpha} = \frac{1}{\sqrt{K}}$$

$$\frac{1}{\alpha} = \frac{1+\sqrt{K}}{\sqrt{K}}$$

Now,

$$\alpha = \frac{\sqrt{K}}{1+\sqrt{K}}$$

Q.25 (1)

Given :
$$A_{(g)} \rightleftharpoons B_{(g)} + C_{(g)} + D_{(g)}$$
initially $\quad 1 \quad\quad 0 \quad\quad 0 \quad\quad 0$
at eq. $\quad 1-x \quad x \quad\quad x \quad\quad x$
Total mole $= 1 + 2x$
Apply mass conservation
Wt. of A at t=0 = wt of mixture at eq.
$1 \times M_{wt.} = [1+2x] \, 2 \times 50$
$M_{wt.} = (1+0.2) \times 100$ (as $x = 0.1$)
$M_{wt.} = 120$

Q.26 (3)

Given: N_2O_4 dissociated
$$N_2O_4 \rightleftharpoons 2NO_2$$
$\quad\quad\quad 1 \quad\quad\quad 0$
at eq. $\quad (1-x) \quad\quad 2x$
Total mole $= 1 - x + 2x$
$\quad\quad\quad\quad = 1 + x$
Mass conservation
wt. of N_2O_4 at t=0 = wt. of NO_2 at eq.
$1 \times 92 = (1+x) \times 82$
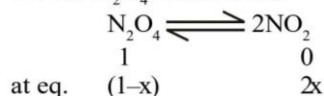
$$\frac{92}{82} - 1 = x$$

$$x\% = \frac{10}{82}\% = 12.2\%$$

Q.27 (2)

We know that $\quad d = \dfrac{D}{1+(n-1)\alpha}$

where n is number of mole of gases produced from one mole of a gas

Q.28 (2)

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$
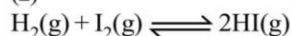
$$\log\frac{K_2}{K_1} = \frac{\Delta H}{2.303R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

$$\log\frac{50}{66.9} = \frac{\Delta H}{2.303R}\left[\frac{1}{623} - \frac{1}{721}\right]$$

After calculation negative value of ΔH is obtained.

Q.29 (2)

$$K = A \, e^{\Delta H/RT}$$

$$\log K = \log A - \frac{\Delta H}{2.303RT} \cdot$$

$$\log K = \log A - \frac{\Delta H}{2.303R} \times \frac{1}{T} \cdot$$

$$\log K = \left[-\frac{\Delta H}{2.303R}\right] \times \frac{1}{T} + \log A.$$

$$\frac{-\Delta H}{2.303R} = 1.$$

$\Delta H = -2.303\,R = -4.606$ cal.

Q.30 (1)
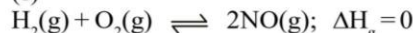
$$H_2(g) + O_2(g) \rightleftharpoons 2NO(g); \quad \Delta H_g = 0$$
If we change the volume the ultimate effect will be due to change in pressure
$\Rightarrow$ If $\Delta n_g = 0$
no effect of change in volume

Q.31 (1)

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad \Delta H° = -198 \text{ Kj}$$
Exothermic reaction
favourable at low temperature $\Delta n_g < 0$
$\Rightarrow$ favourable at high pressure

Q.32 (4)

On adding any reactant equilibrium shifts in forward direction, so amount of product increases.

Q.33 (2)

On adding inert gas at constant pressure effect on equilibrium will be similar to as if volume of container has been increased.

Q.34 (2)

For any physical equilibrium on increasing pressure equilibrium shifts in the direction of higher density.

Q.35 (3)

Solubility of gas is directly proportional to the pressure of gas above liquid.

Q.36 (1)
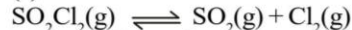
$$SO_2Cl_2(g) \rightleftharpoons SO_2(g) + Cl_2(g)$$
Volume of container is constant
so no effect of addition of inert gas.

Q.37 (4)

Exothermic
$\Rightarrow$ low yield at high temperature
$\quad \Delta n_g < 0$
$\Rightarrow$ low yield at low pressure

Q.38 (1)
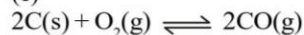
$$2C(s) + O_2(g) \rightleftharpoons 2CO(g)$$
$\Delta n_g = 2 - 1 \Rightarrow 1$
$$\Delta n_g > 0$$
$\Rightarrow$ so on increasing the pressure equilibrium shifted left (or backward direction)
as pressure increases volume decreases.

Q.39 (1)

$$\ln k_p = \frac{-\Delta H}{RT} + \ln A$$

Exothemic $\Delta H < 0$
slope $+Ve$

Q.40 (1) $NH_2^- + H^+ \longrightarrow$

Q.41 (3)
Amphiprotic : can accept and
Release H^+
Only $H_2PO_4^-$ & HCO_3^-

Q.42 (4) Fact based

Q.43 (1) $[OH^-] =$ in pure water.
So as temperature increases K_w decreases $[OH^-]$
decreases.

Q.44 (3) Factual.

Q.45 (2)
In this solution, source of OH^- is water
$\therefore$ $C\alpha = [OH^-]$
$\alpha = = 1.8 \times 10^{-11}$ M
% ionisation $= \mathbf{1.8 \times 10^{-9}\ M}$

Q.46 (4)
$[H^+]_1 = 10^{-2}$; $[H^+]_2 = 10^{-6}$
$= 10^4$

Q.47 (3)
$[H^+] = 0.016$ M
$[H^+][OH^-] = 10^{-14} \Rightarrow [OH^-] = = 6.25 \times 10^{-13}$ M

Q.48 (1)

Inital	Final
pH = 12	pH = 11
$[H^+] = 10^{-12}$ M	$[H^+] = 10^{-11}$ M
$[OH^-] = 10^{-2}$ M	$[OH^-] = 10^{-3}$ M

Inital No. of mole of $OH^- = 10^{-2}$ Final No. of mole of
$OH^- = 10^{-3}$
So no. of mole of OH^- removed $= [.01 - 0.001] = \mathbf{0.009}$

Q.49 (4)
(1) HClNaOH
No. of mili eq. $= \times 100 = 10 \times 100 = 10$
So solution is Neutral
(2) $\times 55 = 5.5 \times 45 = 4.5$
$[H^+] = = 10^{-2}$ M, pH = 2
(3) $\times 10 = 1 \times 90 = 9$ Basic
(4) $\times 75 = 15 \times 25 = 5$
$[H^+] = 0.1$ M, pH = 1

Q.50 (3) $CH_3COOH (aq)\ H^+ (aq) + CH_3COO^- (aq)$
t = 0   0.01
t = eq 0.01 − xx x
$[H^+] = x + 0.01 \approx 0.01$ M
$\therefore$ $K_a = \Rightarrow 1.69 \times 10^{-5} =$
$\therefore$ $[CH_3COO^-] = 1.69 \times 10^{-5}$ M
So, degree of dissociation of $CH_3COOH =$
$= 1.69 \times 10^{-3}$

Q.51 (3)

$$pH = pKa + \log\left[\frac{salt}{acid}\right]$$

50% ionised $\Rightarrow$ [Salt] = [Acid]
$\Rightarrow$ pH = pKa = 4.5 $\Rightarrow$ pOH = 9.5

Q.52 (1)
M_{eq} of HCl $= 25 \times 0.5 = 12.5$
M_{eq} of NaOH $= 10 \times 0.5 = 5$
M_{eq} of HCl remaining $12.5 - 5 = 7.5$
$[H^+] = = 0.15$
pH $= - \log 0.15$
$= 0.8239$

Q.53 (1)

Q.54 (4)
As concentration of solution decreases, degree of dissociation of weak electrolyte increases.

Q.55 (3)
$HF \longrightarrow H^+ + F^-$
$pK_w = pK_a + pK_b$ [For conjugate Acid-Base]
$\Rightarrow pK_a = 14 - 10.87 = 3.17$
$K_a = 6.76 \times 10^{-4}$

Q.56 (2)
$HA \longrightarrow H^+ + A^-$
1 − x   x   x
x = 1%
$\Rightarrow [H^+] = 0.01$
$\Rightarrow$ pH = 2

Q.57 (3)
Ostwald dilution law is valid for weak acid and CH_3COOH is the weak acid.

Q.58 (3)
NaCl Solution : pH is the, pH of water.
As T $\uparrow$, Kw $\uparrow$, & $[H^+] \uparrow$
pH at 25°C < 7

Q.59 (2)
Volume of resulting solution = 100 ml
$[H^+] = = 10^{-3}$
$\Rightarrow$ pH = 3.

Q.60 (2)
% Hydrolysis does not
depend on the conc. in case
of "Weak acid + weak base : Salt"

Q.61 (1)
Weak acid + Strong base : Salt
$CN^- + H_2O\ HCN + OH^-$
$- x\ X\ X$
X can be neglected
$\Rightarrow X = 3.1 \times 10^{-4}$
% Hydrolysis $= \times 100$
$= 2.48\%$

Q.62 (4) Factual

Q.63 (3)
Salt of weak acid & weak base
$[H^+] =$
$pH = [pK_w + pK_a - pK_b]$
$= [14 + 4.8 - 4.78]$
$pH = 7.01$

Q.64 (2)
Solution of HCl & NH_4Cl will be acidic, solution of NaCl neutral whereas solution of NaCN will be basic.

Q.65 (1)
NaCl + HCl : Not the Buffer
and Solution is acidic due to HCl.
$\Rightarrow pH < 7.$

Q.66 (4)
m. equivalent of KOH = 8
m. equivalent of HCOOH = 16
Remaining m. eq. (HCOOH) = 8
Formed m. eq. (HCOOK) = 8
$\Rightarrow$ Acidic Buffer
$pH = pKa = 4 - \log 2$
$= 3.7$
$pOH = 10.3$

Q.67 (2)
$CH_3COOH + OH^- \longrightarrow CH_3COO^- + H_2O$
$t = 0$ 20   20
$t = eq$ –   –   20
So, $[CH_3COO^-] = = 0.1\,M$
$pH = 7 + pK_a + \log C$
$= 7 + 2.37 + \log 10^{-1}$
$= 7 + 2.37 - 0.5 = 8.87$

Q.68 (3)
$pH = 8.7 \Rightarrow pOH = 5.3$
Basic Buffer
$\Rightarrow pOH = pK_b + \log$
$\Rightarrow = 4$
If volume of salt = V ml
$\Rightarrow = 4$

Q.69 (4)
Factual

Q.70 (3)
$K_a = 5 \times 10^{-10}\, pK_a = 10 \log 5 = 9.3$
$pH = pK_b + \log$
$9 = 9.3 + \log - 0.3 = \log$
$0.3 = \log = 2\, V_{ml} = 2\,ml$

Q.71 (1)
$pH = pKa + \log$
$\Rightarrow 5.5 = 5 + \log$
$\Rightarrow = 3.16$
Suppose x m. mole NaOH was added
Acid + Base $\longrightarrow$ Salt
10x 10

$10 - x\ 0\ 10 + x$
$\Rightarrow = 3.16 \Rightarrow x = 5.2\,m.mole$
$\Rightarrow NaoH\,(mass) = \times 40 = 0.208\,g$

Q.72 (2)
$CH_3COOH + NaOH \quad CH_3COONa + H_2O$
time $t = 0$ 40 mmole   20 mmole

time $t = t$ 20 mmole   –20 mmole
$pH = pK_a + \log \Rightarrow pH = pK_a \Rightarrow [H^+] = K_a = 1.8 \times 10^{-5}\,M$

Q.73 (4)
$A_2X_3 \quad 2A^{3+} + 3X^{2-}$
  2y   3y
$K_{sp} = (2y)^2 (3y)^3$
$K_{sp} = 108y^5$

Q.74 (4)
$HgSO_4 \quad Hg^{2+} + SO_4^{2-}\,SS$
$Ksp = S^2$
$\Rightarrow 6.4 \times 10^{-5} = S^2$
$\Rightarrow S = 8 \times 10^{-3}\,mole/L$
$S = 8 \times 10^{-3} \times 10^3\,mole/m^3$
$\Rightarrow S = 8\,mole/m^3$

Q.75 (2)
For ppt $Q_{sp} > K_{sp}$
$CaF_2 \longrightarrow Ca^{2+} + 2F^-$
$Q_{sp} = (Ca^{2+})(F^-)^2$
(1) $Q_{sp} = 12.5 \times 10^{-14}$
(2) $Q_{sp} = 12.5 \times 10^{-10}$
(3) $Q_{sp} = 12.5 \times 10^{-13}$
(4) $Q_{sp} = 12.5 \times 10^{-15}$
Only (2) option will get precipitate.

Q.76 (4) WA Vs SB end point > 7 Phenolphthalein

Q.77 (1) Same as problem Number = 28

Q.78 (3)
$Q_{sp}(AgBr) = [Ag^+][Br^-]$
$\Rightarrow Q_{sp} =$
$= 2 \times 10^{-16}$
$Q_{sp} < K_{sp}$
$\Rightarrow$ No precipitation
$[Ag^+] = = 10^{-7}\,M$

Q.79 (3)
$pH = pK_a + \log \Rightarrow 6 = 5 + \log \Rightarrow 1 = \log$
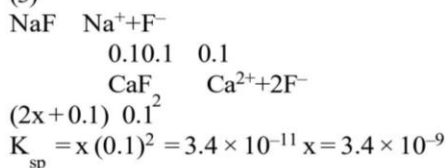$= 10$

Q.80 (1)
$MX_4 \quad M^{4+} + 4X^-\,S\ 4S$

$$K_{sp} = [S][4S]^4$$

$$\Rightarrow K_{sp} = 256S^5 \Rightarrow S = \left(\frac{K_{sp}}{256}\right)^{1/5}$$

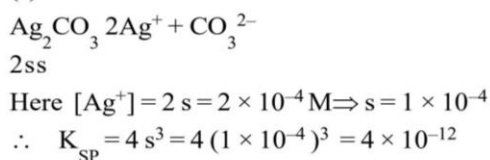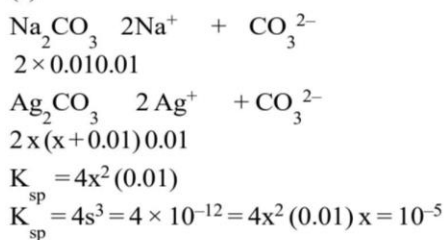**Q.81** (4)
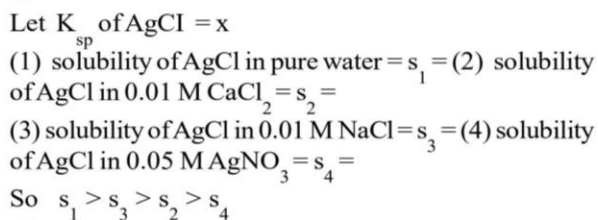$$Li_3Na_3(AlF_6)_2 \; 3Li^+ + 3Na^+ + 2[AlF_6]^{3-}$$
$$3s \qquad\qquad 3s \qquad 2s$$
$$K_{sp} = (3s)^3 \; (3s)^3 \; (2s)^2 = 2916 \; s^8.$$

Q.82 (3)
$$NaF \quad Na^+ + F^-$$
$$0.1 \; 0.1 \quad 0.1$$
$$CaF_2 \quad Ca^{2+} + 2F^-$$
$$(2x+0.1) \; 0.1$$
$$K_{sp} = x\,(0.1)^2 = 3.4 \times 10^{-11} \; x = 3.4 \times 10^{-9}$$

Q.83 (1)
$$Ag_2CO_3 \; 2Ag^+ + CO_3^{2-}$$
$$2s \; s$$
Here $[Ag^+] = 2s = 2 \times 10^{-4}M \Rightarrow s = 1 \times 10^{-4}$
$$\therefore \quad K_{SP} = 4s^3 = 4\,(1 \times 10^{-4})^3 = 4 \times 10^{-12}$$

Q.84 (3)
$$Na_2CO_3 \; 2Na^+ \;+\; CO_3^{2-}$$
$$2 \times 0.01 \; 0.01$$
$$Ag_2CO_3 \quad 2\,Ag^+ \;+ CO_3^{2-}$$
$$2x \; (x+0.01) \; 0.01$$
$$K_{sp} = 4x^2\,(0.01)$$
$$K_{sp} = 4s^3 = 4 \times 10^{-12} = 4x^2\,(0.01) \; x = 10^{-5}$$

Q.85 (3)
Let K_{sp} of AgCI $= x$
(1) solubility of AgCl in pure water $= s_1 =$ (2) solubility of AgCl in 0.01 M $CaCl_2 = s_2 =$
(3) solubility of AgCl in 0.01 M NaCl $= s_3 =$ (4) solubility of AgCl in 0.05 M $AgNO_3 = s_4 =$
So $s_1 > s_3 > s_2 > s_4$

Q.86 (1)
$K_{SP}\,(Ba\,CrO_4) = 2.4 \times 10^{-10} \, M^2$
$[CrO_4^{-2}] = 6 \times 10^{-4} \; K_{SP}\,(BaCrO_4) = [Ba^{+2}]\,[CrO_4^{-2}] \; 2.4 \times 10^{-10}$
$$\Rightarrow [Ba^+] \times 6 \times 10^{-4} = 2.4 \times 10^{-10}$$
$[Ba^+] = 4 \times 10^{-7} M$ **Ans.**

Q.87 (1)
pH $= 4 \Rightarrow [H^+] = 10^{-4}M \Rightarrow [OH^-] = 10^{-10}M$
$Al\,(OH)_3 \; Al^{+3} + 3\,OH^-$
$K_{sp}\,(Al\,(OH)_3) = [Al^{+3}]\,[OH^-]^3$
$[Al^{3+}]\,[OH^-]^3 = 1 \times 10^{-33}$
$[Al^{3+}]\,(10^{-10})^3 = 1 \times 10^{-33} \Rightarrow [Al^{+3}] = 10^{-3}M$

Q.88 (4)
Higher the concentration of H^+, higher is the solubility of $Fe(OH)_3$.
solubility of $Fe(OH)_3$ is maximum in 0.1 M H_2SO_4

Q.89 (1)
order of solubility : Complex formation > Pure water > Common ion effect.
AgBr form complex $[Ag\,(NH_3)_2]^+$ in NH_3 so solubility is maximum in NH_3 (aq).

Q.90 (3)
$$H_2A \; H^+ + HA^-$$
$$10^{-5} =$$
$$HA^- \; H^+ + A^{2-}$$
$$5 \times 10^{-10} =$$
$$H_2A \; 2H^+ + A^-$$
$$K_{overall} = 5 \times 10^{-10} \times 10^{-5}$$
$$= 5 \times 10^{-15}$$
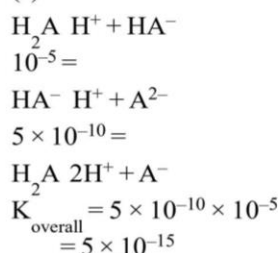
EXERCISE-III

JEE-ADVANCED
COMPREHENSION/STATEMENT/MATCHING/MCQ

Q.1 (A,C)
$$AB \rightleftharpoons A^+ + \qquad B^- \qquad K_1$$
$$y \qquad y-x$$
$$AB + B^- \rightleftharpoons AB_2^- \quad K_2$$
$$y-x \quad x$$

$$\Rightarrow K_1 = (y-x)y \quad K_2 = \frac{x}{y-x}$$
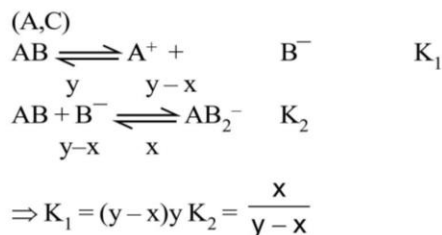
$$\Rightarrow \frac{k_1}{k_2} = \frac{y}{x}\,(y-x)^2$$

Q.2 (A,C)
Q.3 (A,B,C) From given reactions.

$$(i) = -(iii); \quad \frac{1}{2}\,(i) = -(iv); \qquad \frac{1}{2}\,(iii) = -(ii)$$

Q.4 (C,D)

Q.5 (B,C)

Q.6 (C,D)
Addition of solids have no effect on equilibrium and temperature favours endothermic direction while increasing pressure will shift equilibrium in backward direction as Δn_g is +ve.

Q.7 (B,C)

Exothermic $\Rightarrow$ low temp

∴ forward reaction favoured

High temp backward

Q.8 (C,D)

As given :

$HgO(s)+4I^-(aq)+H_2O(\ell) \rightleftharpoons HgI_4^{2-}(aq)+2OH^-(aq)$,

$K = \dfrac{[HgI_4^{2-}][OH^-]^2}{[I^-]^4}$

as, $OH^{\ominus} \uparrow$ $HgI^{2-} \downarrow$

$H_2O(\ell) \uparrow OH^{\ominus} \uparrow$

Q.9 (C,D)

Introduction of inet gas at constant Pressure will increase $\uparrow$ & volume $\downarrow$ the Pressure of gases of equilibrium

$\Rightarrow$ equilibrium shifted forward

Q.10 (C,D)

$NaNO_3(s) \rightleftharpoons NaNO_2(s) + O_2(g)$

$\Delta H > 0$ endothermic

High temperature

∴ forward reaction favoured

1000 pressure

High pressure $\rightarrow$ Reverse reaction

Q.11 (B,C,D)

According to

$K_p = \dfrac{P_{PCl_3(g)} \times P_{Cl_2(g)}}{P_{PCl_5(g)}} = \dfrac{(n_{PCl_3(g)})_{eq.} \times (n_{Cl_2(g)})_{eq.}}{V \times (n_{PCl_5(g)})_{eq.}}$

and on adding inert gas at constant pressure effect on equilibrium will be similar to as if volume of container has been increased.

Q.12 (C,D)

As few moles of CO(g) are introduced into the vessel second equilibrium shifts backward, decreasing the concentration of Cl_2. So, first equilibrium will go forward.

Q.13 (A,C)

Addition of solids have no effect on equilibrium and temperature favours endothermic direction while increasing pressure will shift equilibrium in backward direction as Δn_g is +ve.

Q.14 (A,B,C)

Addition of inert gas at constant volume has no effect on equilibrium concentrations.

Q.15 (B, D)

$pK_a(H_3O^+) = -1.74 = pK_b$ of OH^-

$pK_a + pK_b = 14$ only for conjugate acid base pair.

$\alpha = 1.8 \times 10^{-9}$ or 1.8×10^{-7} % for H_2O.

Q.16 (A, B, C)

$pK_w = -\log K_w = -\log 1 \times 10^{-12} = 12$.

Q.17 (B,C)

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

$[H^+] = [OH^-]$

$\Rightarrow [H^+]^2 = 10^{-12}$; $[H^+] = 10^{-6}$; $pH = -\log[H^+] = -\log 10^{-6} = 6$.

H_2O is neutral because $[H^+] = [OH^-]$ at 373 K even when pH = 6.

(D) is not correct at 373 K. Water cannot become acidic.

Q.17 (B,C)

(A) pH of 10^{-8} m sol. of HCl is 6.97

(consider the H^+ from H_2O also)

(B) $H_2PO_4^- \xrightarrow{-H^+} HPO_4^{2-}$

(C) $Kw = [H^+][OH^-]$

On $\uparrow$ temp $[H^+][OH^-]$

both $\uparrow \Rightarrow Kw \uparrow$

(D) $HA + NaOH \rightarrow NaA + H_2O$

   C C/2   C–C/2

$pH = pKa + \log \dfrac{salt}{acid}$

Q.18 (B, C, D)

(B), (C) and (D) are the mixtures of conjugate acid-base pairs.

Q.19 (A, D)

(A) $[H^+] = 10^{-2}$ and $[OH^-] = 10^{-2}$

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

This leads complete neutralisation

so, $pH = 7 = \dfrac{2+12}{2}$

(D) $[H^+] = 10^{-5}$ and $[OH^-] = 10^{-5}$

$[H^+] + [OH^-] \longrightarrow H_2O$

This leads complete neutralisation

so, $pH = 7 = \dfrac{5+9}{2}$

Q.20 (A,B,C)

$HCl \longrightarrow H^+ + Cl^-$

0.09 – 0.09   0.09 0.09

$Cl_2HCCOOH \rightleftharpoons Cl_2COO^- + H^+$

0.1 – y y   y + 0.09 + x

We have, $y + 0.09 + x = 10^{-1} = 0.10$

$x + y = 0.01$

Also, $K_{CH_3COOH} = 10^{-5} = \dfrac{0.1 \times y}{0.01 - y} \approx \dfrac{0.01}{0.1}$

∴ $x \approx 0.01$

∴ $K_{Cl_2HCOOH} = \dfrac{x \times 0.1}{0.09 - 0.01} = \dfrac{0.01 \times 0.1}{0.08} = \mathbf{1.25 \times 10^{-2}}$

Q.21 (A,B,C)

MW of $ClCH_2COOH = 44.5$

No. of Moles of acid $= \dfrac{9.45}{94.5} = 0.1$

∴ [acid] $= 0.1 \times 2 = 0.2$ M

$ClCH_2COOH \rightleftharpoons ClCH_2COO^- + H^+$

0.2(1 – α) 0.1 α $10^{-2} = 0.2 \alpha$

$$\alpha = \frac{10^{-2} \times 10^5}{2} = 0.05$$

Q.22 (A, C, D)

(A) In 0.6 m M HCOOH solution

$$K_a = \frac{[H^+]^2}{C - [H^+]} \Rightarrow 8 \times 10^{-4} = \frac{[H^+]^2}{6 \times 10^{-4} - [H^+]}$$

$$\therefore \quad [H^+] = 4 \times 10^{-4} \text{ M}.$$

So solution in (A), (C) & (D) are ISOHYDRIC.

Q.23 (A, B)

$$\text{Total } [H^+] = \sqrt{K_{a_1}C_1 + K_{a_2}C_2}$$

$$= \sqrt{\left(3.6 \times 10^{-4} \times \frac{0.5}{500} \times 100\right) + \left(8 \times 10^{-4} \times \frac{0.1}{500} \times 400\right)}$$

$$\therefore \quad [H^+] = 10^{-2} \text{ M}.$$

For HN_3, $[N_3^-] = \frac{K_a[HN_3]}{[H^+]} = \frac{3.6 \times 10^{-4} \times 0.5}{0.01 \times 500} \times 100$

$$= 3.6 \times 10^{-3} \text{ M}.$$

For HOCN, $[OCN^-]$

$$= \frac{K_a[HOCN]}{[H^+]} = \frac{8 \times 10^{-4} \times 0.1 \times 400}{0.01 \times 500} = 6.4 \times 10^{-3} \text{ M}.$$

Q.24 (A, C)

As K_a of acid increases, K_b of its conjugate base decreases.

Q.25 (B, C)

On the basis of ostwald dilution law, number of H^+ ions will increase but increase in volume will be more. Therefore, $[H^+]$ decreases, pH increases.

Q.26 (B, C, D)

Let BA be this salt $BA \rightarrow B^+ + A^-$

A^- does not undergo hydrolysis because HA is strong acid. B^+ undergoes hydroysis

h = h = degree of hydrolysis where K_h = Hydrolysis constant = .

h $\propto$ greater the hydrolysis constant greater the h(degree of hydrolysis).

h $\propto$ greater the K_h lesser the h.

Hydrolysis is endothermic, K_h increases with temperature and h also increase with temperature.

h $\propto$ V = volume of salt solution hence h increases with dilution. K_h =

Both K_w and K_b change with temperature, hence K_h changes with temperature.

Hence, statement(B) is correct. h increases if K_b decreases, statement(C) correct.

It is found that as temperature increase, K_w and K_b increase but increase in K_w is greater than increase in K_b.

Hence, h increases with increase in temperature. or h decrease in temperature., hence statement.

(D) is correct.

(D) is not correct from explanation of (B).

Q.27 (A, D)

(A) $\frac{[H_3AsO_4]}{[H_2AsO_4^-]} = \frac{[H^+]}{K_1} = \frac{10^{-8}}{2.5 \times 10^{-4}} = \frac{1}{25000}$ $\therefore$

$[H_3AsO_4] << [H_3AsO_4^-]$.

(B) $\frac{[H_2AsO_4^-]}{[HAsO_4^{2-}]} = \frac{[H^+]}{K_2} = \frac{10^{-8}}{5 \times 10^{-8}} = \frac{1}{5}$

(C) $\frac{[AsO_4^{3-}]}{[HAsO_4^{2-}]} = \frac{K_3}{[H^+]} = \frac{2 \times 10^{-13}}{10^{-8}} = \frac{1}{50000}$ $\therefore$

$[AsO_4^{3-}] << [HAsO_4^{2-}]$.

Q.28 (A, B, C)

(A) $H_2CO_3 + OH^- \longrightarrow HCO_3^- + H_2O$

moles   1.5   1

      0.5   −1

so it is a buffer solution.

(B) $H_2CO_3 + OH^- \longrightarrow HCO_3^- + H_2O$

moles 1.5 2−0.51.5

    $HCO_3^- + OH^- \longrightarrow CO_3^{2-} + H_2O$
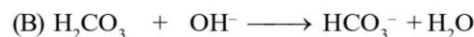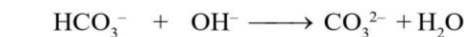
moles 1.5 0.5−   −0.5

so it is a buffer solution.

(C) $NH_4OH + H^+ \longrightarrow NH_4^+ + H_2O$
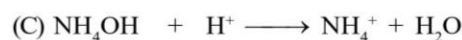
moles   541   − 4

so it is a buffer solution.

Q.29 (A,B)

(A) A buffer solution is a solution which contains weak acid and its conjugate base. it is acidic buffer.

(B) Basic buffer contains weak base and its conjugate acid.

(C) is wrong because it does not show change in pH on adding small amount of acid or base.

(D) is wrong ; all the above statements are not correct.
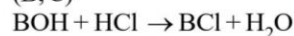
Q.30 (A, D)

$HIn \longrightarrow H^+ \quad\quad\quad + In^-$

$$K_{In} = \frac{[H^+][In^-]}{[HIn]} \Rightarrow \frac{[In^-]}{[HIn]} = \frac{K_{In}}{[H^+]} = \frac{10^{-9}}{10^{-9.6}} = 10^{0.6} = 4$$

$\therefore$ % of $[In^-]$ in solution $= \frac{4}{5} \times 100 = 80\%$

so pink colour will be visible.

Q.31 (B, C)

$BOH + HCl \rightarrow BCl + H_2O$

100 m 0.5 V 20 M

100 M − 0.5 V 0 = 80 M 14−a

$$pOH = pKb + log \frac{salt}{base}$$

$$5 = pKb + log \frac{20M}{80M}$$

$\Rightarrow$ pkb = 5 – log 0.25 $\Rightarrow$ pkb = 5.6
$\Rightarrow$ Kb = 2.5 × 10⁻⁶
greater than 10⁻⁶

Q.32 (C, D)

In $AgNO_3$ solution, the solubility of AgCN will decrease as compared to pure water because of common ion effect of Ag^+ ion.

In NH_3 solution and buffer of pH = 5, the solubility of AgCN will increase due to complex formation in case of NH_3 solution and hydrolysis of CN^- ions in case of buffer of pH = 5.

Q.33 (A,B)

$K_{sp} = 1.1 \times 10^{-11} = (1.4 \times 10^{-4})^{x+y} x^x \cdot y^y$
so we have x + y = 3 (by comparing values)

so, $x^x \cdot y^y = \dfrac{1.1 \times 10^{-11}}{1.4 \times 1.4 \times 1.4 \times 10^{-12}} = \dfrac{110}{1.96 \times 1.4} = 4$

Hence x = 1, y = 2 or y = 1, x = 2

Q.34 (B,D) Facutal

Q.35 (A, B)

H_2SO_4 is a strong acid and it completely dissociated in H_2O. Hence its K_{a_1} and K_{a_2} are determined in CH_3COOH.

Also H_2SO_4 is neutral while HSO_4^- because the – ve charge has more affinity towards H^+ ion. Hence choices (A) and (B) are correct while (C) is incorrect. As H_2SO_4 is completely dissociated in water so a 0.01 M H_2SO_4 is completely dissociated and its [H^+] ion conc. will be equal to 0.02 M.

Hence choice (D) will be incorrect.

Q.36 (B)

$CO_2(g) + C(s) \rightleftharpoons 2CO(g)$
t = 0   0.1   t = t_eq.   0.1 – x   2x
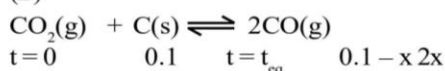
$\dfrac{(0.1 - x)44 + (2x \times 28)}{0.1 + x} = 36 \qquad \Rightarrow x = \dfrac{1}{30}$

Total moles $= 0.1 + \dfrac{1}{30} = \dfrac{2}{15}$

Q.37 (A) Moles of CO_2 at eq. $= 0.1 - x = \dfrac{1}{15}$

Moles of CO at eq. $= 2x = \dfrac{2}{30} = \dfrac{1}{15}$

$P_{CO_2} = \dfrac{0.082 \times 900}{15 \times 0.82} = 6$ atm

$P_{CO} = \dfrac{1}{15} \times \dfrac{0.082}{0.82} \times 900 = 6$ atm

$\therefore K_P = \dfrac{6 \times 6}{6} = 6$ atm

Q.38 (B)

$n_C = 0.1$
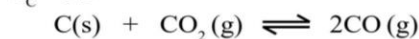
$C(s) + CO_2(g) \rightleftharpoons 2CO(g)$
t = 0   0.1   n
t = t_eq.   –   n – 0.1   0.2

$P_{CO} = \dfrac{0.2 \times 0.082 \times 900}{0.82} = 18$ atm

$K_P = 6 = \dfrac{(18)^2}{P_{CO_2}}$; $P_{CO_2} = 54$ atm

$\therefore \dfrac{(n - 0.1)(0.082)(900)}{0.82} = 54$

n = 0.7

Q.39 (D)

Solublity of gas is favourable at high pressure and this process is exothermic hence solubility will be more at low temperature.
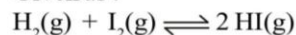
Q.40 (C)

Since density of gold decreases after melting therefore it is favourable at low pressure and high temperature.

Q.41 (A,B)

Number of moles will remain unchanged but due to decreased volume pressure will get increased and also the concentrations.

Q.42 (C)

Given as :
$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$
initally   1   3
At equilbrium   1–x/2   3–x/2   x
addition of 2 mole H_2.

$3 - \dfrac{x}{2} - \dfrac{x}{2}$ $3 - \dfrac{x}{2} - \dfrac{x}{2}$ x+x
= 3–x   3–x   2x

$\Rightarrow \dfrac{(x)^2}{\left(1 - \dfrac{x}{2}\right)\left(3 - \dfrac{x}{2}\right)} = \dfrac{(2x)^2}{(3 - x)(3 - x)}$

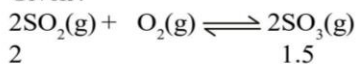$\Rightarrow 2x = 3 \Rightarrow x = \dfrac{3}{2}$

x = 1.5

Q.43 (C)

$K_C = \dfrac{(2x)^2}{(3 - x)(3 - x)} = \dfrac{9}{\left(\dfrac{9}{4}\right)} = 4$
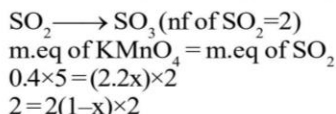
$K_C = K_P$ because $\Delta n_g = 0$
$K_C = K_P = 4$

Q.44 (B)
Given :
$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$
$$2 \qquad\qquad 1.5$$

conc. $= \dfrac{2-2x}{5} \quad \dfrac{1.5-x}{5} \quad \dfrac{2x}{5}$

$SO_2 \longrightarrow SO_3$ (nf of $SO_2 = 2$)
m.eq of $KMnO_4$ = m.eq of SO_2
$0.4 \times 5 = (2.2x) \times 2$
$2 = 2(1-x) \times 2$

$\Rightarrow \quad 1-x = 1/2 \Rightarrow x = \dfrac{1}{2}$

$[SO_2] = \dfrac{1}{5} \; ; [O_2] = \dfrac{1}{5}$

$[SO_3] = \dfrac{1}{5}$

$K_C = 5$

Q.45 (D) Facutal

Q.46 (A)
Since K_a of CH_3COOH & K_b of NH_4OH are same so degree of hydrolysis of CH_3COO^- & NH_4^+ are exactly same.

Q.47 (C)
Facutal

Q.48 (A)
For SrF_2 in pure water
$\quad 4s_1^3 = K_{sp}$
For SrF_2 in 0.1 M NaF solution
$\quad s_2 (0.1)^2 = K_{sp}$
$\Rightarrow \quad 4s_1^3 = s_2 (0.01)$
$\Rightarrow \quad 4s_1^3 = s_1 \times \dfrac{256}{10^6} (0.01)$
$\Rightarrow \quad s_1 = 8 \times 10^{-4} M$
$\therefore \quad K_{sp} = 4s_1^3 = \mathbf{2.048 \times 10^{-9}}$

Q.49 (C)
$[Sr^{2+}]_i = 0.0011 = 11 \times 10^{-4} M$
$[Sr^{2+}]_f = 2 \times 10^{-4} M$
$\therefore \quad [Sr^{2+}]$ precipitated $= (11-2) \times 10^{-4} M$
$= 9 \times 10^{-4} M$
$\quad [F^-]$ needed for this precipitation $= 2 \times 9 \times 10^{-4} = 18 \times 10^{-4} M$
Also, $[Sr^{2+}]_f [F^-]_f^2 = K_{sp} = 2.048 \times 10^{-9}$
But, $[Sr^{2+}]_f = 2 \times 10^{-4} M$
$\therefore \quad [F^-]_f = 3.2 \times 10^{-3} M$
$\therefore \quad$ Total $[F^-]$ needed $= 3.2 \times 10^{-3} + 18 \times 10^{-4} = 5 \times 10^{-3} M$

$\therefore \quad$ NaF needed for 100 ml solution $= \dfrac{5 \times 10^{-3} \times 42}{10}$

$= \mathbf{0.021\ g}$
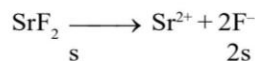
Q.50 (B)
$$SrF_2 \longrightarrow Sr^{2+} + 2F^-$$
$$s \qquad\qquad 2s$$
F^- will react with H^+ to produce HF
$F^- + H^+ \rightleftharpoons HF$
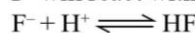
$K = \dfrac{1}{K_a} = \dfrac{[HF]}{[H^+][F^-]} = \dfrac{7}{10^{-5}}$

$\therefore \quad [HF] = 7 \times 10^5 [F^-][H^+]$ ($\because [H^+] = 10^{-5}$; pH=5)
$\qquad\qquad = 7 \times 10^5 [F^-] \times 10^{-5} = 7[F^-]$
Here $[F^-] + [HF] = 2s$

$\therefore \quad [F^-] = \dfrac{s}{4}$

$K_{sp} = s \left(\dfrac{s}{4}\right)^2 = 2.048 \times 10^{-9}$

$\therefore \quad s = 3.2 \times 10^{-3}$ mol/L

Q.51 (A) q, s; (B) p ;(C) p ;(D) r
(A) $\Delta n_g = 2 - 4 = -2$ and $K_P = K_C (RT)^{\Delta n_g}$
(B) $\Delta n_g = 2 - 1 = 1$ and $K_P = K_C (RT)^{\Delta n_g}$
(C) $\Delta n_g = 2 - 1 = 1$ and $K_P = K_C (RT)^{\Delta n_g}$
(D) K_P is not defined.

Q.52 A→p; B→q; C→s; D→r

$K_P = K_C (RT)^{\Delta n_g}$

Q.53 A–p,t ; B–q, r; C–q,s
(A) $\Delta n_g = 0$
(B) $\Delta n_g = -1$
(C) $\Delta n_g = 2$

Q.54 (A) → P,R,S; (B) → P,Q,R,S; (C) → P,Q,R,S ; (D) → Q
As we know

$\dfrac{K_P}{K_C} = (RT)^{\Delta n_g}$

K_P & K_C ratio depend on T & Δn_g
if we take T=0°C than
$(RT) > 1$

(A) if $\Delta n_g < 0$ $\dfrac{K_P}{K_C} < 1 \Rightarrow K_P < K_C$

if $\Delta n_g > 0$ $\dfrac{K_P}{K_C} > 1 \Rightarrow KP > K_C$

if we take T=0°C than
P, R, S
(B) Addition of inert gas at const pressure means pressure of equilibrium gases will decrease equilibrium shift where mole of gases are high due to the conc of reactant means equilibrium shifted to forward
$\Rightarrow \Delta n_g > 0$
But pressure is constant $\Rightarrow$ volume ↑

⇒ conc. of reactants ↓
P, Q, R, S
(C) K_p° always dimensonless P, Q, R, S
(D) T↓ forward shift ⇒ ΔH > 0

Q.55 A–S, B–S, C-Q

(A) $[H^+] = \dfrac{200 \times 1.225 \times \dfrac{25}{100} \times 2}{98}$

= 1.25

$[OH^-] = 0.525 \times \dfrac{800}{1000} \times 3 = 1.26$

Remaining $[OH^-] = 10^{-2}$
⇒ pOH = 2
⇒ pH = 12
Indicator having range 11.4 to 13.

(B) pH = 11 – log2 + log $\dfrac{0.8}{0.1}$

= 11 + 2 log 2
= 11.6
Indicator having range 11.4 to 13.
(C) HCl m.eq = 5
NaOH m.eq = 13
↓
Remaining NaOH = 8
m.eq of HA = 10
Ha + OH⁻ ⟶ A– + H₂O
10   8
2   08

pH= P^{Ka}+log $\dfrac{[A^-]}{[HA]}$
= 5 + log 4
⇒ 5.6
Indcator having range 4.6 to 6.4

Q.56 [50]
Given:– $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ K_p =0.5

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

now,
$\Delta n_g = 2 - 2 = 0$
∴ $K_p = K_C$
$K_C = 50$

Q.57 [64] For this reaction there is no change in equilibrium constant by change of volume.

Q.58 [16]
Q.59 [120]
Given :
$A_{(g)} \rightleftharpoons B_{(g)} + C_{(g)} + D_{(g)}$
initially   1   0   0   0
at eq.   1–x   x   x   x
Total mole = 1 + 2x
Apply mass conservation
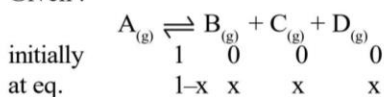
Wt. of A at t=0 = wt of mixture at eq.
$1 \times M_{wt.} = [1+2x] 2 \times 50$
$M_{wt.} = (1+0.2) \times 100$ (as x = 0.1)
$M_{wt.} = 120$

Q.60 [1] If $\Delta G^o = 0$

$\Delta G^o = -2.303\ RT\ \log K_p$

$\log K_p = 0$

(∵ log1 = 0)

$K_p = 1$.

Q.61 [4.0%]

$K_h = \dfrac{10^{-14}}{6.2 \times 10^{-10}} = \dfrac{1}{6.2} \times 10^{-4}$

$\dfrac{K_h}{c} = 1.6 \times 10^{-3}$
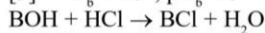
Assuming h ≪ 1

$h^2 = \dfrac{K_h}{c}$

h = 0.04
Percent hydrolysis = 4%

Q.62 [10]

$\dfrac{\alpha_2}{\alpha_1} = \sqrt{\dfrac{K_a.C_2}{K_a.C_1}} = \sqrt{\dfrac{C_2}{C_1}} = 10$

Q.63 [9] $K_b = 10^{-5}$, $pK_b = 5$
BOH + HCl → BCl + H₂O
At half neutralization, 50% of the base is converted to its salt, with strong acid HCl, it forms a basic buffer.
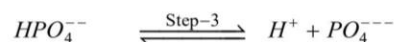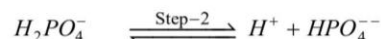$pOH = pK_b + \log \dfrac{[salt]}{[base]}$

$pOH = 5 + \log \dfrac{[salt]}{[base]}$
[salt] = [baes]
pOH = 5
pH = 14 – pOH = 9

Q.64 [3] $H_3PO_4 \xrightarrow{Step-1} H^+ + H_2PO_4^-$

$H_2PO_4^- \xrightarrow{Step-2} H^+ + HPO_4^{--}$

$HPO_4^{--} \xrightarrow{Step-3} H^+ + PO_4^{---}$

Q.65 [10,000] $[H^+]_1 = 10^{-2}$; $[H^+]_2 = 10^{-6}$
$= 10^4$

EXERCISE-IV

**JEE-MAIN
PREVIOUS YEAR'S**

Q.1 (2)

	A	+	B	$\rightleftharpoons$	C	+	D
t = 0	1		1		1		1
t_{eq}	1–x		1–x		1+x		1+x

$\Rightarrow \dfrac{(1+x)^2}{(1-x)^2} = 100 \qquad \Rightarrow \dfrac{1+x}{1-x} = 10$

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

$\Rightarrow x = \dfrac{9}{11}$

$\Rightarrow [D] = 1 + \dfrac{9}{11}$

$\Rightarrow [D] = 1.818$
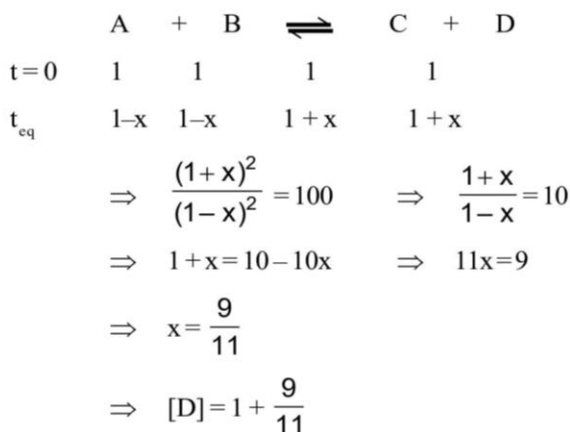
Q.2 (4)
From thermodynamics

$\ln k = \dfrac{-\Delta H^\circ}{RT} + \dfrac{\Delta S^\circ}{R}$

for exothermic reaction,
$\Delta H = -ve$

slope $= \dfrac{-\Delta H^\circ}{R} = +ve$

So from graph, line should be A & B.

Q.3 (1)
$NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g)$
5.1 g
0.1 mol – 0.03   0.03 mol   0.03 mol

$V = 3L, \quad T = 327^\circ C \quad \dfrac{0.98}{2} \quad \dfrac{0.98}{2}$

$K_P = P_{NH_3} P_{H_2S} \qquad\qquad PV = nRT$

$K_P = \dfrac{0.98}{2} \times \dfrac{0.98}{2} \qquad P \times 3 = 0.06 \times 0.0821 \times 600$

$\qquad\qquad\qquad P = \dfrac{0.06 \times 0.821 \times 200}{2}$

$K_P = 0.243 \qquad P = 0.98$

Q.4 (4)

$\Delta G^\circ = \left(120 - \dfrac{3}{8} T\right) = 0$

Then T = 320 K
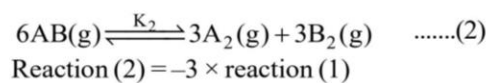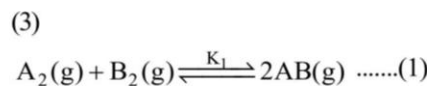Hence T > 320 K Y formed
T < 320 K X formed

Q.5 (1)
$N_2 + 3H_2 \rightleftharpoons 2NH_3$
equm   x   3x P_1
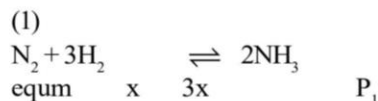
$P_T = 4x \quad K_P = \dfrac{P_1^2}{x \times 27 \times 3}$

$x = \left(\dfrac{P}{4}\right)$

$P_1 = \sqrt{27x^4 K_P}$

$\sqrt{27}\left(K_P\right)^{1/2}\left(\dfrac{P_T}{4}\right)^2 = \dfrac{3^{1/2} K_P^{1/2} p^2}{16}$
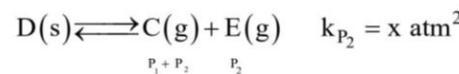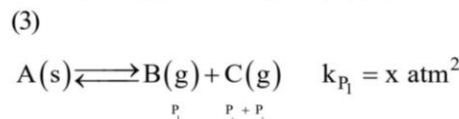
Q.6 (3)

$A_2(g) + B_2(g) \underset{}{\overset{K_1}{\rightleftharpoons}} 2AB(g)$ ....(1)

$6AB(g) \overset{K_2}{\rightleftharpoons} 3A_2(g) + 3B_2(g)$ ....(2)
Reaction (2) = –3 × reaction (1)

$\therefore K_2 = \left(\dfrac{1}{K_1}\right)^2 \Rightarrow K_2 = K_1^{-3}$

Q.7 (1)

$A + 2B \rightleftharpoons 2C + D$
Initially conc. a   1.5a
at eq.   a–x 1.5 (a – 2x) 2x   x
at equilibrium a – x = 1.5 a – 2x
0.5a = x
a = 2x
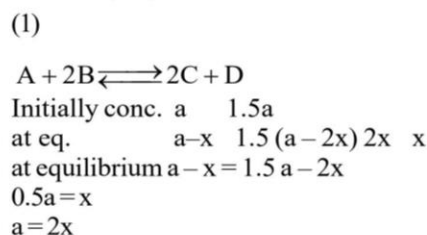
$k_C = \dfrac{(2x)^2 x}{(a-x)(1.5a-2x)^2} = \dfrac{4x^2 . x}{(x)(x)^2} = 4$

Q.8 (3)

$A(s) \rightleftharpoons B(g) + C(g) \qquad k_{P_1} = x \; atm^2$
$\qquad\quad P_1 \quad P_1 + P_2$

$D(s) \rightleftharpoons C(g) + E(g) \qquad k_{P_2} = x \; atm^2$
$\qquad\quad P_1 + P_2 \quad P_2$

$k_{P1} = P_1(P_1 + P_2)$

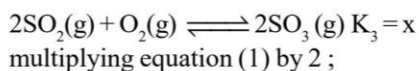$k_{P2} = P_2(P_1 + P_2)$
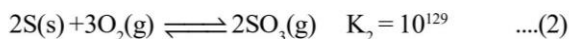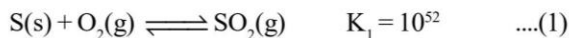
$k_{P1} + k_{P_2} = (P_1 + P_2)^2$

$x + y(P_1 + P_2)^2$
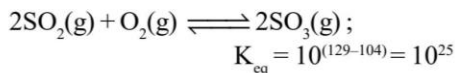
$P_1 + P_2 = \sqrt{x + y}$

$2(P_1 + P_2) = \sqrt{x + y}$

$P_{Total} = P_B + P_C + P_E = 2(P_1 + P_2) = 2\sqrt{x + y}$

Q.9 (2) $K_p = K_c (RT)^{\Delta ng}$

Q.10 (3)

$S(s) + O_2(g) \rightleftharpoons SO_2(g) \qquad K_1 = 10^{52} \qquad ....(1)$

$2S(s) + 3O_2(g) \rightleftharpoons 2SO_3(g) \qquad K_2 = 10^{129} \qquad ....(2)$

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad K_3 = x$

multiplying equation (1) by 2 ;

$2SO(s) + 2O_2(g) \rightleftharpoons 2SO_2(g) \qquad K_1' = 10^{104} \quad ....(3)$

$\Rightarrow$ Substracting (3) from (2) ; we get

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) ;$
$\qquad K_{eq} = 10^{(129-104)} = 10^{25}$

Q.11 (1) $\Delta G° = -RT \ln k$
if $K < 1 \Rightarrow \Delta G° > 0$

Q.12 (4) if $\Delta n_g \neq 0$
$Kp \neq Kc$

Q.13 (1) In option (2)- Δn_g is -ve therfore increase in pressure will bring reaction in forward direction. In option (3)- as the reaction is exothermic therefore increase in temperature will decrease the equilibrium constant.
In option (4)- Equilibrium constant changes only with temperature.
Hence, option (2), (3) and (4) are correct therefore option (1) is incorrect choice.

Q.14 (2) $2H_2(g) + 2NO(g) \rightleftharpoons N_2(g) + 2H_2O(g)$

$K_c = \dfrac{k_f}{k_b} = \dfrac{[N_2][H_2O]^2}{[H_2]^2[NO]^2}$

Given for forward reaction, rate $= k_f[NO]^2[H_2]$
for reverse reaction rate $= k_b[N_2][H_2O]^2$

Q.15 (4)

Q.16 (4) $A \rightleftharpoons B + C \,......(i) \quad K_{eq}^{(1)}$

$B + C \rightleftharpoons P \,.......(ii) \quad K_{eq}^{(2)}$

$A \rightleftharpoons P$
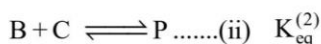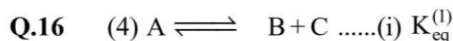
K_{eq} (overall) $= K_{eq}^{(1)} K_{eq}^{(2)}$

Q.17 (2) At equilibrium,
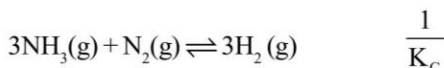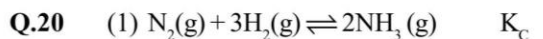rate of forward reaction = Rate of backward reaction

Q.18 [16.00]

$X \; + \; Y \rightleftharpoons 2Z$

$t = 0 \quad 1 \qquad 1.5 \qquad 0.5$
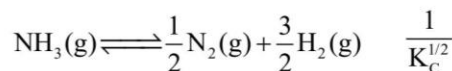$t = eq \quad 1-0.25 \quad 1.5-0.25 \quad 0.5+0.5$

$\therefore K_{eq} = \dfrac{(1)^2}{0.75 \times 1.25} = \dfrac{x}{15}$

$\Rightarrow x = \dfrac{15}{0.75 \times 1.25} = 16$

Q.19 (2) $\because$ Given reaction is endothermic
$\therefore$ On decreasing temperature backward reaction will be favoured. On adding N_2, pressure is increased at constant T, and volume would also be constant so no change is observed.

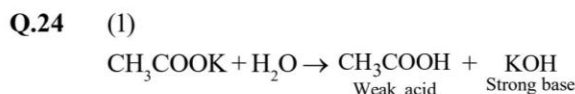**Q.20** (1) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad K_C$

$3NH_3(g) + N_2(g) \rightleftharpoons 3H_2(g) \qquad \dfrac{1}{K_C}$

For

$NH_3(g) \rightleftharpoons \dfrac{1}{2}N_2(g) + \dfrac{3}{2}H_2(g) \qquad \dfrac{1}{K_C^{1/2}}$

$\dfrac{1}{K_C^{1/2}} = \dfrac{1}{(64)^{1/2}} = \dfrac{1}{8}$

Q.21 (1) $K_p = K_C(RT)^{\Delta n_g}$
$= K_C(RT)^{1-3/2}$
$= K_C(RT)^{-1/2}$
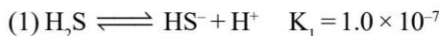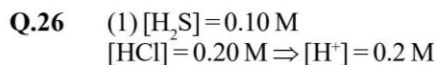$\Rightarrow K_C = K_p(RT)^{1/2}$

Q.22 [3]

Q.23 [3]

Q.24 (1)

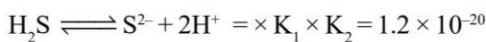$CH_3COOK + H_2O \rightarrow \underset{Weak\ acid}{CH_3COOH} + \underset{Strong\ base}{KOH}$

Hence nature of solution is basic.

Q.25 (2) Methyl orange shows Red(pinkish) color in Acidic medium & yellow color in basic medium since original solution is basic so
initial color $\Rightarrow$ yellow & Titrated with acid so
Final color $\Rightarrow$ pinkish (red)

Q.26 (1) $[H_2S] = 0.10\,M$
$[HCl] = 0.20\,M \Rightarrow [H^+] = 0.2\,M$

(1) $H_2S \rightleftharpoons HS^- + H^+ \quad K_1 = 1.0 \times 10^{-7}$

(2) $HS \rightleftharpoons S^{2-} + H^+ \quad K_2 = 1.2 \times 10^{-13}$

So,

$H_2S \rightleftharpoons S^{2-} + 2H^+ = \times K_1 \times K_2 = 1.2 \times 10^{-20}$
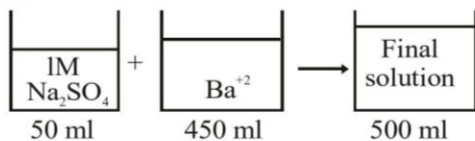
So,

$[S^{2-}] = \dfrac{1.2 \times 10^{-20} \times [H_2S]}{[H^+]^2} = \dfrac{1.2 \times 10^{-20} \times 10^{-1}}{4 \times 10^{-2}}$

$= 3 \times 10^{-20}\,M$

* All the $[H^+]$ will come from strong acid $[HCl]$ only.

Q.27 (2)

Concentration of SO_4^{-2} in Ba^{+2} solution

$M_1 V_1 = M_2 V_2$
$1 \times 50 = M_2 \times 500$

$M_2 = \dfrac{1}{10}$

for just precipitaion
$I.P = K_{sp}$

$\left[Ba^{+2}\right]\left[SO_4^{-2}\right] = K_{sp}(BaSO_4)$

$\left[Ba^{+2}\right] \times \dfrac{1}{10} = 10^{-10}$

$\left[Ba^{+2}\right] = 10^{-9}$ M in 500 ml solution

For calculation of $\left[Ba^{+2}\right]$ in original solution (450 ml)

$M_1 \times 450 = 10^{-9} \times 500$

$M_1 = \dfrac{500}{450} \times 10^{-9} = 1.11 \times 10^{-9}$ M

[M1 = molarity of Ba^{+2} in original solution (450 ml)]
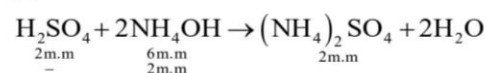
Q.28 (1) $Ca(OH)_2 + Na_2SO_4 \rightarrow CaSO_4 + 2NaOH$
100 m mol   14 m mole   –   –
–   –   – 14 m mol   28 m mol
$w_{CaSO4} = 14 \times 10^{-3} \times 136 = 1.9$ gm

$[OH^-] = \dfrac{28}{100} = 0.28M$

Q.29 (3) $8 \times 10^{-12} = (2S' + 0.1)^2 S'$
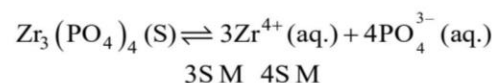or $S' = 8 \times 10^{-10}$ M

Q.30 (2)

$H_2SO_4 + 2NH_4OH \rightarrow (NH_4)_2 SO_4 + 2H_2O$
2 m.m   6 m.m   2 m.m
–   2 m.m

$pOH = 4.7 + \log \dfrac{4}{2} = 5$

$pH = 14 - 5 = 9$

Q.31 (1) Fact based.

Q.32 (4)

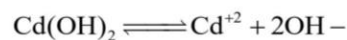$Zr_3 (PO_4)_4 (S) \rightleftharpoons 3Zr^{4+} (aq.) + 4PO_4^{3-} (aq.)$
3S M   4S M

$K_{sp} = [Zr^{4+}]^3 [PO_4^{3-}]^4 = (3S)^3 . (4S)^4 = 6912 S^7$

$\therefore S = \left(\dfrac{K_{sp}}{6912}\right)^{1/7}$

Correct option : (4)

Q.33 (4) $K_{sp} = 4 (s)^3$
$= 4 \times (1.84 \times 10^{-5})^3$

$Cd(OH)_2 \rightleftharpoons Cd^{+2} + 2OH-$
S'   S' $(10^{-2} + S') = 10^{-2}$
$S' \times (10^{-2})^2 = 4 \times (1.84 \times 10^{-5})^3$
$S' = 4 \times (1.84)^3 \times 10^{-11}$
$(S') = 2.491 \times 10^{-10}$ M

Q.34 (4) $Al(OH)_3 \rightleftharpoons Al^{+3} + 3OH^-$
S' $0.2 + 3(S') \cong 0.2$
$S' \times (0.2)^3 = k_{sp} = 2.4 \times 10^{-24}$
$(S') = 3 \times 10^{-22}$ M

Q.35 (2) For the salt of strong acid and weak base

$[H^+] = \sqrt{\dfrac{K_w \times C}{K_b}}$

$[H^+] = \sqrt{\dfrac{10^{-14} \times 2 \times 10^{-2}}{10^{-5}}}$

$-\log[H^+] = 6 - \dfrac{1}{2} \log 20$

$\therefore pH = 5.35$

Q.36 [10.60 to 10.60]

$M_{H_2SO_4} \Rightarrow \dfrac{9.8}{98 \times 100} = 10^{-3}$

$M_{NaOH} \Rightarrow \dfrac{4}{40 \times 100} = 10^{-3}$

$= \dfrac{40 \times 10^{-3} - 10 \times 10^{-3} \times 2}{50} = \dfrac{20}{50} \times 10^{-3}$
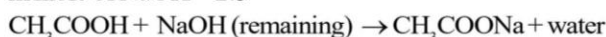
$[OH^-] = \dfrac{2}{5} \times 10^{-3}$

$pOH = 3.397$
$pH = 10.603$

Q.37 [5.22 to 5.24] m mole of acetic acid in 20 mL = 2
m mole of HCl in 20
m mole of NaOH = 2.5
$CH_3COOH + NaOH (remaining) \rightarrow CH_3COONa + water$
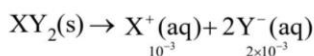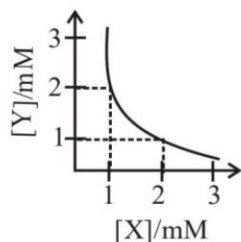2   3/2   0   0
0.5   0   3/2

$pH = pK_a + \log \dfrac{3/2}{2}$

$= 4.75 + \log 3 = 4.75 + 0.4771 = 5.2271 \approx 5.23$
$= 4.74 + 0.48 = 5.22$

Q.38 (2) Oxalic acid is a primary standard solution while H_2SO_4 is a secondary standard solution.

Q.39 (3)

$$XY_2(s) \to \underset{10^{-3}}{X^+}(aq) + \underset{2\times10^{-3}}{2Y^-}(aq)$$

$K_{sp} = [X^+][Y^-]^2$

or $K_{sp} = 10^{-3} \times (2\times10^{-3})^2$ or $k_{sp} = 4\times10^{-9}\,M^3$

Q.40 (2) Theory based.

Q.41 (2) $Q = [Pb^{2+}][Cl^-]^2$

$$= \frac{300\times0.134}{400} \times \left[\frac{100\times0.4}{400}\right]^2$$

$$= \frac{3\times0.134}{4}\times(0.1)^2$$

$$= 0.105\times10^{-2}$$

$$= 1.005\times10^{-3}$$

$$\boxed{Q > Ksp}$$

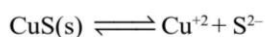**Q.42** [4] $Cr(OH)_3 \to \underset{s}{Cr^{+3}} + \underset{3s}{3OH^-}$

$k_{sp} = s.(3s)^3$

$\Rightarrow \quad 6\times10^{-31} = 27.s^4$

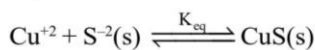$$\Rightarrow \quad s = \left(\frac{6}{27}\times10^{-31}\right)^{1/4}$$

$[OH^-] = 3s$

$$= 3\times\left(\frac{6}{27}\times10^{-31}\right)^{1/4} = (18\times10^{-31})^{1/4}M$$

Q.43 (3) K_{sp} value of CuS is very low $= 10^{-36}\,(3.6\times10^{-36})$ due to low K_{sp} value Cu^{+2} ion gets precipitated very quickly even with very low concentration of S^{-2} ion.

$CuS(s) \rightleftharpoons Cu^{+2} + S^{2-}$

$K_{sp} = [Cu^{+2}][S^{-2}]$
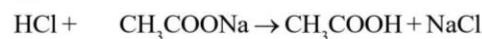
$Cu^{+2} + S^{-2}(s) \xrightarrow{\;K_{eq}\;} CuS(s)$

$$K_{eq} = \frac{1}{K_{sp}} = \frac{1}{3.6\times10^{-36}}$$

$$= \frac{10^{36}}{3.6}$$

Due to high value of K (equilibrium constant) CuS precipitated quickly.

Q.44 (1) For titration between HCl and NaOH, pH at equivalence point is found to be 7.

Q.45 (2)

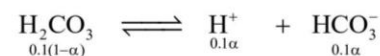|	HCl +	$CH_3COONa \to$	CH_3COOH +	$NaCl$
Initial	100×0.1	200×0.1		
	$= 10\,mmol$	$= 20\,mmol$		
Final	0	10 mmol	10 mmol	10 mmol
moles				

CH_3COOH and CH_3COONa both are present. Both form acidic buffer.

Q.46 [37] At 30 bar pressure mass of CO_2 in 1 kg water $= 44$ gm

At 3 bar pressure mass of CO_2 in 1 kg water $= 4.4$ gm

Moles of CO_2 in 1 kg water $= 0.1$

$$\underset{0.1(1-\alpha)}{H_2CO_3} \rightleftharpoons \underset{0.1\alpha}{H^+} + \underset{0.1\alpha}{HCO_3^-}$$

$$Ka_1 = \frac{[H^+][HCO_3^-]}{[H_2CO_3]}$$

$$4\times10^{-7} = \frac{0.1\alpha^2}{1-\alpha} \approx 0.1\alpha^2$$

$$\alpha = 2\times10^{-3}$$

$[H^+] = 0.1\,\alpha = 2\times10^{-4}$; pH $= 3.7$

$\qquad = 37\times10^{-1}$

Q.47 [02.00] $AB_2 \rightleftharpoons \underset{s}{A^{2+}}(aq) + \underset{2s}{2B^-}(aq)$

$K_{sp} = 4s^3 = 3.2\times10^{-11}$

$\Rightarrow s^3 = 8\times10^{-12}$

$s = 2\times10^{-4}$

Q.48 (2) (A) 0.01 M HCl

$[H^+] = 10^{-2}$, pH $= -\log 10^{-2} = 2$

pOH = 14 − 2 = 12

(B) 0.01 M NaOH

$[OH^-] = 10^{-2}$, $pOH = -\log[OH]$

= 2

(C) 0.01 M CH_3COONa

$pH = 7 + \dfrac{1}{2}[pK_a \log 0.01]$

$pH > 7 \Rightarrow pOH < 7$

(D) 0.01 M NaCl, pH = 7, pOH = 7

Order of pOH value A > D > C > B

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PREVIOUS YEAR'S

Q.1 (A,B,D)

(A) $\Delta H_2 - \Delta H_1 = C_{P\,(rxn)}(T_2 - T_1)$ and C_p depends on temperature. Hence enthalpy also depends on temperature.

(B) $CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$ $Kp = (P_{CO_2})_{at\,equilibrium}$

For a given reaction.

$K_{eq.}$ depends only on temperature.

(C) K_{eq} depends only on temperature.

(D) Enthalpy of reaction is independent of the catalyst. Catalyst generaly changes activation energy.

Q.2 (B)

$X_2(g) \rightleftharpoons 2 \times (g)$

$1 - \dfrac{\beta}{2}$ β

$K_P = \dfrac{\left[\dfrac{\beta}{\left(1+\dfrac{\beta}{2}\right)}\right]^2 \times 2^2}{\dfrac{1-\dfrac{\beta}{2}}{1+\dfrac{\beta}{2}}\times 2} = \dfrac{\beta^2}{1-\dfrac{\beta^2}{4}}\times 2$
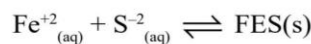
$K_P = \dfrac{8\beta^2}{4-\beta^2}$

Q.3 (C) $\Delta G^0 = (+)ve$ $\therefore -RT\ln K_P = \Delta G^0 = (+)ve$

$K_P < 1$

Also β cant be 0.7 otherwise K_P will have to be (+)ve

Q.4 [8.92 or 8.93]

$Fe^{+2}_{(aq)} + S^{-2}_{(aq)} \rightleftharpoons FES(s)$

0.03 M   0.1M

(0.03−x) (0.1−x)

$\simeq y \simeq 0.07$

$K_c \gg 10^3 \Rightarrow 0.03 - x \simeq 0 \simeq y$

$\Rightarrow x = 0.03$

$K_c = 1.6 \times 10^{17} = \dfrac{1}{y \times 0.07}$

$y = \dfrac{10^{-17}}{1.6 \times 0.07} = 8.928 \times 10^{-17} = Y \times 10^{-17}$
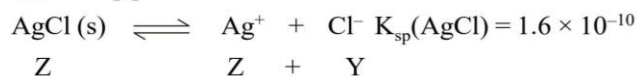
$y = 8.93$

Q.5 [0.25] $K_{eq.} = \dfrac{[B]}{[A]}$

$K_{1000} = \dfrac{10}{1} = 10$ and $K_{2000} = \dfrac{100}{1} = 100$

Now, $\dfrac{\Delta G^0_{1000}}{\Delta G^0_{2000}} = \dfrac{(-RT\ell n k_{eq})_{1000}}{(-RT\ell n k_{eq})_{2000}} = \dfrac{1000 \times \ell n 10}{2000 \times \ell n 100}$

= 0.25

Q.6 [7]

$AgCl\,(s) \rightleftharpoons Ag^+ + Cl^-$ $K_{sp}(AgCl) = 1.6 \times 10^{-10}$

  Z   Z   +   Y

$CuCl\,(s) \rightleftharpoons Cu^+ + Cl^-$ $K_{sp}(CuCl) = 10^{-6}$

  Y   Z   +   Y

  $Z\,(Z+Y) = 1.6 \times 10^{-10}$

and $Y\,(Z+Y) = 10^{-6}$

$\Rightarrow (Z+Y)^2 = 1.6 \times 10^{-10} + 10^{-6}$

$\Rightarrow (Z+Y)^2 \approx 10^{-6}$

$\Rightarrow Z + Y = 10^{-3}$

We know

$\Rightarrow Z\,(Z+Y) = 1.6 \times 10^{-10}$

$\Rightarrow Z \times 10^{-3} = 1.6 \times 10^{-10}$

$\Rightarrow Z = 1.6 \times 10^{-7}$

$\Rightarrow 1.6 \times 10^{-x} = 1.6 \times 10^{-7}$

$\Rightarrow x = 7$

Q.7 [4.47]

$$S = \sqrt{K_{sp}\left(\frac{[H^+]}{K_a}+1\right)} = \sqrt{2\times10^{-10}\left(\frac{10^{-3}}{10^{-8}}+1\right)}$$

$$= \sqrt{2\times10^{-5}} = 4.47\times10^{-3}$$

Q.8 [0.11] No. of eq. of oxalic acid = No. of eq. of NaOH

or $\dfrac{5.00\times0.10}{1000}\times2 = \dfrac{9.0\times M}{1000}\times1$

$\therefore$ Molarity of NaOH solution $= \dfrac{1}{9} = 0.11M$

Q.9 [2.30 TO 3.00]

$B+HA \longrightarrow BH^+ + A^-$

0.1M, V ml

0.1V m mol 0.1 V m mol 0.1 V 0.1V

$$\left[BH^+\right] = \frac{0.1V}{2V} = 0.5M$$

pH at eq. pt = 6 to 6.28

$$pH = 7 - \frac{1}{2}\left[pK_b + \log 0.05\right]$$

So $pK_b = 2.30 - 2.80$
     Possible

Solution 2

at V=6 ml rxn is complete

So V=3ml is half of eq. pt

at which   pH=11

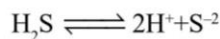pOH=(14–11)   =pK_b+log 1

pK_b=3

Q.10 [0.20]

For ppt, $[Zn^{+2}][S^{-2}] = K_{sp}$

$$\left[S^{-2}\right] = \frac{1.25\times10^{-22}}{0.05}$$

$$= 2.5\times10^{-21}\,M$$

$$H_2S \rightleftharpoons 2H^+ + S^{-2}$$

$$K_{Net} = 10^{-21} = \frac{\left[H^+\right]^2 \times 2.5\times10^{-21}}{0.1}$$

$$\left[H^+\right]^2 = \frac{1}{25}$$

$$\left[H^+\right]^2 = \frac{1}{5}M = 0.2M$$