7.EQUILIBRIUM

Single Correct Answer Type

1. A solution which is 10^{-3}M each in $Mn^{2+}, Fe^{2+}, Zn^{2+}$ and Hg^{2+} is treated with 10^{-16} M sulphide ion. If K_{sp} of MnS, FeS, ZnS and HgS are 10^{-15}, $10^{-23}, 10^{-20}$ and 10^{-54} respectively, which one will precipitate first?
a) FeS b) MgS c) HgS d) ZnS

2. Which of the following salts will not undergo hydrolysis in water?
a) Sodium sulphate b) Ammonium sulphate
c) Aluminium sulphate d) All the salts will hydrolyse

3. K_{sp} of $Mg(OH)_2$ is 4.0×10^{-6}. At what minimum pH, Mg^{2+} ions starts precipitating 0.01 MgCl
a) $2 + \log 2$ b) $2 - \log 2$ c) $12 + \log 2$ d) $12 - \log 2$

4. For the reversible reaction
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
at 500°C, the value of K_p is 1.44×10^{-5} when the partial pressure is measured in atmosphere. The corresponding value of K_c with concentration in mal L^{-1} is
a) $\dfrac{1.44 \times 10^{-5}}{(0.082 \times 500)^{-2}}$ b) $\dfrac{1.44 \times 10^{-5}}{(8.314 \times 773)^{-2}}$ c) $\dfrac{1.44 \times 10^{-5}}{(0.082 \times 773)^{2}}$ d) $\dfrac{1.44 \times 10^{-5}}{(0.082 \times 773)^{-2}}$

5. For the system $A(g) + 2B(g) \rightleftharpoons C(g)$ the equilibrium concentration is
$A = 0.06 \text{ mol L}^{-1}; B = 0.12 \text{ mol L}^{-1}$
$C = 0.216 \text{ mol L}^{-1}$ The K_{eq} for the reaction is
a) 250 b) 416 c) 4×10^{-3} d) 125

6. The pH of a dilute solution of acetic acid was found to be 4.3. The addition of a small crystal of sodium acetate will cause pH to
a) Becomes less than 4.3 b) Become more than 4.3
c) Remain equal to 4.3 d) Unpredictable

7. The pH of a solution of weak base at neutralization with strong acid is 8. K_b for the base is
a) 1.0×10^{-4} b) 1.0×10^{-6} c) 1.0×10^{-8} d) None of there

8. Auto-ionisation of liquid NH_3 is
$2NH_3 \rightleftharpoons NH_4^{\oplus} + NH_2^{\oplus}$
With $K_{NH_3} = [NH_4^{\oplus}][NH_2^{\oplus}] = 10^{-30}$ at −50°C
Number of amide ions $(NH_2^{\ominus})$, present per mm^3 of pure liquid NH_3 is
a) 602 b) 301 c) 200 d) 100

9. 1 mol of N_2 is mixed with 3 mol of H_2 in a litre container. If 50% of N_2 is converted into ammonia by the reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, then the total number of moles of gas at the equilibrium are
a) 1.5 b) 4.5 c) 3.0 d) 6.0

10. pH signifies:
a) Puissance de hydrogen b) $-\log[H^{\oplus}]$
c) All the above d) $14 - pOH$

11. The pK_a of acetyl salicylic acid (aspirin) is 3.5. The pH of gastric juice in human stomach is about 2-3 and the pH in the same intestine is about 8. Aspirin will be
a) Unionized in the small intestine and in the stomach
b) Completely ionsed in the small intestine and in the stomach
c) Ionized in the stomach and almost unionized in the small intestine
d) Ionized in small intestine and almost unionized in the stomach

12. Passing H_2S gas into a mixture of Mn^2, Ni^2, Cu^2 and Hg^2 ions in an acidified aqueous solution precipitates
a) CuS and HgS b) MnS and CuS c) MnS and NiS d) NiS and HgS

13. In the formation of nitric acid, N_2 and O_2 are made to combine. Thus, $N_2 + O_2 \rightleftharpoons 2NO + \text{Heat}$ which of the following condition will favour the formation of NO?
a) Low temperature b) High temperature c) Freezing point d) All are favourable

14. The decomposition of N_2O_4 to NO_2 is carried out at 280°C in chloroform. When equilibrium is reached, 0.2 mol of N_2O_4 and 2×10^{-3} mol of NO_2 are present in a 2L solution. The equilibrium constant for the reaction
$N_2O_4 \rightleftharpoons 2NO_2$ is
a) 1×10^{-2} b) 2×10^{-3} c) 1×10^{-5} d) 2×10^{-5}

15. Solubility of salt A_2B_3 is 1×10^{-4}, its solubility product is
a) 1.08×10^{20} b) 1.08×10^{18} c) 2.6×10^{-18} d) 1.08×10^{-18}

16. In 1L saturated solution of AgCl [K_{sp}(AgCl)1.6 10^{10}], 0.1 mole of CuCl [K_{sp}(CuCl)1.0 10^{6}] is added. The resultant concentration of Ag in the solution is 1.6 10^{x}. The value of 'x' is
a) 3 b) 5 c) 7 d) 9

17. The conjugate acid of $NH_2^{\ominus}$ is
a) NH_3 b) NH_2OH c) $NH_4^{\oplus}$ d) N_2H_4

18. In alkaline solution, the following equilibrium exist
a. $S^{2-} + S \rightarrow S_2^{2-}$ equilibrium constant K_1
b. $S_2^{2-} + S \rightarrow S_3^{2-}$ equilibrium constant K_2
K_1 and K_2 have values 12 and 11, respectively?
$S_3^{2-} \rightarrow S^{2-} + 2S$. What is equilibrium constant for the reaction
a) 132 b) 7.58×10^{-3} c) 1.09 d) 0.918

19. If ammonia is added to pure water, the concentration of a chemical species already present will decrease. The species is
a) $O_2^{\ominus}$ b) $\overset{\ominus}{O}H$ c) $H_3O^{\oplus}$ d) H_2O

20. The equilibrium constant for a reaction
$A + B \rightleftharpoons C + D$ is 1.0×10^{-2} at 298 and is 2.0 at 373 K
The chemical process resulting in the formation of C and D is
a) Exothermic b) Endothermic c) Unpredictable d) None

21. When 0.2 M solution of acetic acid is neutralized with 0.2 M NaOH in 500 mL of water, the pH of the resulting solution will be: [pK_a of acetic acid = 4.74]
a) 12.67 b) 7.87 c) 8.87 d) 7

22. For the reaction $N_2O_4(g) \rightleftharpoons 2NO_2(g)$, the value of K_p is 1.7×10^{3} at 500 K and 1.7×10^{4} at 600 K. Which of the following is/are correct?
a) The proportions of NO_2 in the equilibrium mixture is increased by decrease in pressure
b) The standard enthalpy change for the forward reaction is negative

c) Units of K_p are atm^{-1}
d) At 500 K the degree of dissociation of N_2O_4 decreases by 50% by increasing the pressure by 100%

23. If pK_b for fluoride ion at 25°C is 10.83, the ionization constant of hydrofluoric acid in water at this temperature is
a) 1.74×10^{-5} b) 3.52×10^{-3} c) 6.75×10^{-4} d) 5.38×10^{-2}

24. Solubility product constant [K_{sp}] of salts of types MX, MX_2 and M_3X at temperature 'T' are 4.0×10^{-8}, 3.2×10^{-14} and 2.7×10^{-15}respectively. Solubilities (mol, dm^{-3}) of the salts at temperature 'T' are in the order
a) $MX > MX_2 > M_3X$ b) $M_3X > MX_2 > MX$ c) $MX_2 > M_3X > MX$ d) $MX > M_3X > MX_2$

25. Which of the following represents the conjugate pair of NH_3?
a) $NH_2^{\ominus}$ b) $NH_4^{\oplus}$ c) Both (a) and (b) d) N^{3-}

26. In the dissociation of PCl_5 as
$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$
If the degree of dissociation is α at equilibrium pressure P, then the equilibrium constant for the reaction is
a) $K_p = \frac{\alpha^2}{1 + \alpha^2 P}$ b) $K_p = \frac{\alpha^2 P^2}{1 - \alpha^2}$ c) $K_p = \frac{P^2}{1 - \alpha^2}$ d) $K_p = \frac{\alpha^2 P}{1 - \alpha^2}$

27. 0.1 mole of CH_3NH_2 ($K_b = 5 \times 10^{-4}$) is mixed with 0.08 mole of HCl diluted to 1 L. What will be the H^+ concentration in the solution?
a) 8×10^{-2} M b) 8×10^{-11} M c) 1.6×10^{-11} M d) 8×10^{-5} M

28. The number of S^{2-} ions present in 1 L of 0.1 M H_2S $\left[K_{a(H_2S)} = 10^{-21}\right]$ solution having $\left[H^{\oplus}\right] = 0.1$ M is:
a) 6.023×10^3 b) 6.023×10^4 c) 6.023×10^5 d) 6.023×10^6

29. In decinormal solution, CH_3COOH acid is ionized to the extent of 1.3% = 0.11, what is the pH of the solution?
a) 3.89 b) 2.89 c) 4.89 d) Unpredictable

30. The gatric juice in our stomach contains enough HCl to make the hydrogen ion concentration about 0.01 mol L^{-1}. The pH of gastric juice is
a) 0.01 b) 1 c) 2 d) 14

31. HX is a weak acid ($K_a = 10^{-5}$). It forms a salt NaX (0.1 M on reacting with caustic soda. The degree of hydrolysis of NaX is
a) 0.01% b) 0.0001 % c) 0.1 % d) 0.5 %

32. Phenolphthalein does not act as an indicator for the titration between
a) HCl and NH_4OH b) $Ca(OH)_2$ and HCl c) NaOH and H_2SO_4 d) KOH and CH_3COOH

33. Which of the following salt is basic?
a) HOCl b) NaOCl c) $NaHSO_4$ d) NH_4NO_3

34. The solubility products of $Al(OH)_3$ and $Zn(OH)_2$ are $\sqrt[3]{8.5 \times 10^{-23}}$ and 1.8×10^{-14}, respectively. If NH_4OH is added to a solution containing Al^{3+} and Zn^{2+} ions, then substance precipitated first is
a) $Al(OH)_3$ b) $Zn(OH)_2$ c) Both (a) and (b) d) None of these

35. Which of the following metal sulphides has maximum solubility in water?
a) CdS ($K_{sp} = 36 \times 10^{-30}$)
b) FeS ($K_{sp} = 11 \times 10^{-20}$)
c) HgS ($K_{sp} = 32 \times 10^{-54}$)
d) ZnS ($K_{sp} = 11 \times 10^{-22}$)

36. Consider the reaction
$A(g) + B(g) \rightleftharpoons C(g) + D(g)$
Which occurs in one step The specific rate constant are 0.25 and 5000 for the forward and reverse reaction, respectively. The equilibrium constant is
a) 2.0×10^{-4} b) 4.0×10^2 c) 5.0×10^{-5} d) 2.5×10^{-6}

37. Given the equilibrium constants
$HgCl^{\oplus} + Cl^{\ominus} \rightarrow HgCl_2, K_1 = 3 \times 10^6$
$HgCl_2 + Cl^{\ominus} \rightarrow HgCl_3^{\ominus}, K_2 = 8.9$
The equilibrium constant for the disproportionation equilibrium
$2HgCl_2 \rightarrow HgCl^{\oplus} + HgCl_3^{\ominus}$ is
a) -3.3×10^5 b) 3×10^{-5} c) 3.3×10^5 d) 3×10^{-6}

38. If the equilibrium constant of $BOH \rightleftharpoons B^{\oplus} + \overset{\ominus}{O}H$ at 25°C is 2.5×10^{-6}, then equilibrium constant for $BOH + H^{\oplus} \rightleftharpoons B^{\oplus} + H_2O$ at the same temperature is

a) 4.0×10^{-9}
b) 4.0×10^{5}
c) 2.5×10^{8}
d) 2.5×10^{-6}

39. If equal volumes of $BaCl_2$ and NaF solutions are mixed, which of these combination will not give a precipitate? (K_{sp} of $BaF_2 = 1.7 \times 10^{-7}$)
a) 10^{-3} $BaCl_2$ and 2×10^{-2}M NaF
b) 10^{-3} M $BaCl_2$ and 1.5×10^{-2}M NaF
c) 1.5×10^{-2} $BaCl_2$ and 10^{-2}M NaF
d) 2×10^{-2} M $BaCl_2$ and 2×10^{-2}M NaF

40. Which of the following will not change the concentration of ammonia in the equilibrium
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g);\ \Delta H = -x$ kJ
a) Increase of pressure
b) Increase of temperature
c) Decrease of volume
d) Addition of catalyst

41. At certain temperature 50% of HI is dissociated into H_2 and I_2, the equilibrium constant is
a) 1.0
b) 3.0
c) 0.5
d) 0.25

42. The pH of a solution is 5.00. To this solution, sufficient acid is added to lower the pH to 2.00. The corresponding increase in $H_3O^{\oplus}$ ion concentration is
a) 1000 times
b) 2.5 times
c) 100 times
d) 5 times

43. Two buffer solutions, A and B each made with acetic acid and sodium acetate differ in their pH by one unit, A has salt: acid $= x{:}\,y$, B has salt : acid $= y{:}\,x$. If $x > y$, then the value of $x{:}\,y$ is
a) 10,000
b) 3.17
c) 6.61
d) 2.10

44. If the dissociation constant of NH_4OH is 1.8×10^{-5}, the concentration of $\overset{\ominus}{\text{OH}}$ ions, in mol L^{-1} of 0.1 M NH_4OH is
a) 1.8×10^{-6}
b) 1.34×10^{-3}
c) 4.20×10^{-2}
d) 5.0×10^{-2}

45. Pure ammonia is placed in a vessel at a temperature where its dissociation constant (α) is appreciable. At equilibrium,
a) K_p does not change significantly with pressure
b) α does not change with pressure
c) The concentration of NH_3 does not change with pressure
d) The concentration of hydrogen is less than that of nitrogen

46. Which one of the following is acid salt?
a) Na_2S
b) Na_2SO_4
c) $NaHSO_3$
d) Na_2SO_2

47. Methyl orange gives red colour in
a) KOH solution
b) HCl solution
c) Na_2CO_3 solution
d) NaCl solution

48. A certain weak acid has a dissociation constant of 1.0×10^{-4}. The equilibrium constant for its reaction with a strong base is
a) 1.0×10^{-4}
b) 1.0×10^{-10}
c) 1.0×10^{-10}
d) 1.0×10^{-14}

49. 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
a) Adding a suitable catalyst
b) Adding an inert gas
c) Decreasing the volume of the container
d) Increasing the amount of CO(g)

50. Which of the following salts will not change the pH of pure water on dissociation?
a) KCl
b) $AlCl_3$
c) Na_2CO_3
d) $Al_2(SO_4)_3$

51. K_{sp} of $Mg(OH)_2$ is 1×10^{-12}, 0.01 M $MgCl_2$ will be precipitating at the limiting pH:
a) 8
b) 9
c) 10
d) 12

52. K_{sp} for lead iodate $[Pb(IO_3)_2]$ is 3.2×10^{-14} at a given temperature. The solubility in mol L^{-1} will be
a) 2.0×10^{-5}
b) $(3.2 \times 10^{-7})^{1/2}$
c) (3.8×10^{-7})
d) 4.0×10^{-6}

53. The equilibrium constants K_{p_1} and K_{p_2} for the reactions $A \rightleftharpoons 2B$ and $P \rightleftharpoons Q + R$, respectively, are in the ratio of 2: 3. If the degree of dissociation of A and P are equal, the ratio of the total pressure at equilibrium is,

a) 1: 36 b) 1: 9 c) 1: 6 d) 1: 4

54. The pH of an aqueous solution of $Ba(OH)_2$ is 10. If the K_{sp} of $Ba(OH)_2$ is 1×10^{-9}, then the concentration of Ba^{2+} ions in the solution in mol L^{-1} is

a) 1×10^{-2} b) 1×10^{-4} c) 1×10^{-1} d) 1×10^{-5}

55. In which of the following solvents will AgBr has highest solubility?

a) 10^{-3} M NaBr b) 10^{-3}M NH_4OH c) Pure water d) 10^{-3} M HBr

56. The pK_a of acetyl salicylic acid (aspirin) is 3.5. The pH of gastric juice in human stomach is about 2-3 and the pH in the small intestine is about 8. Aspirin will be

a) Unionised in the small intestine and in the stomach
b) Completely ionized in the small intestine and in the stomach
c) Ionized in the stomach and almost unionized in the small intestine
d) Ionized in the small intestine and almost unionized in the stomach

57. A mixture of weak acid is 0.1 M in HCOOH($K_a = 1.8 \times 10^{-4}$) and 0.1 M in HOCN ($K_a = 3.1 \times 10^{-4}$). Hence, $[H_3O^{\oplus}]$ is

a) 7.0×10^{-3} M b) 4.1×10^{-4} M c) 0.20 M d) 4.1×10^{-3} M

58. A constant temperature, the equilibrium constant (K_p) for the decomposition reaction $N_2O_4 \rightleftharpoons 2NO_2$ is expressed by $K_p = (4x^2p)/(1 - x^2)$, where $p =$ pressure and $x =$ extent of decomposition. Which one of the following statements is true?

a) K_p increases with increase in p

b) K_p increases with increase in x

c) K_p increases with decrease in x

d) K_p remains constant with change in p and x

59. Which one of the following is true for any diprotic acid, H_2X?

a) $K_{a_2} > K_{a_1}$ b) $K_{a_1} > K_{a_2}$ c) $K_{a_2} = \frac{1}{K_{a_1}}$ d) $K_{a_2} = K_{a_1}$

60. Which of the following will have the largest pH?

a) M/10 HCl b) M/100 HCl c) M/10 NaOH d) M/100 NaOH

61. Fear or excitement, generally cause on to breathe rapidly and it results in the decrease of CO_2 concentration in blood. In what way will it change the pH of blood

a) pH will increase b) pH will decrease c) No change d) pH will adust to 7

62. The pH of an acid buffer can be raised by 2 units by

a) Increasing the concentration of both weak acid and salt by two moles
b) Increasing the concentration of both the acid and salt by 10 times
c) Diluting the solution by 10 times
d) Increasing the concentration of the salt by 10 times and decreasing concentration of the acid by 10 time

63. An acid-base indicator has a $K_a = 3.0 \times 10^{-5}$. The acid form of the indicator is red and the basic form is blue. Then

a) pH is 4.05 when indicator is 75% red b) pH is 5.00 when indicator is 75% blue
c) Both (a) and (b) are correct d) None of these

64. The dissociation constant of a substituted benzoic acid at 25°C is 1.0×10^{-4}. The pH of 0.01 M solution of its sodium salt is

a) 3 b) 7 c) 8 d) 6

65. In which of the following reaction, the yield of the products does not increase by increase in the pressure?

a) $N_2(g) + O_2(g) = 2NO(g)$ b) $2SO_2(g) + O_2(g) = 2SO_3(g)$

c) $N_2(g) + 3H_2(g) = 2NH_3(g)$ d) $PCl_3(g) + Cl_2(g) = PCl_5(g)$

66. The value of K_{sp} is $HgCl_2$ at room temperature is 4.0×10^{-15}. The concentration of $Cl^{\ominus}$ ion in its aqueous solution at saturation point is

a) 1×10^{-5} b) 2×10^{-5} c) 2×10^{-15} d) 8×10^{-15}

67. Which buffer solution out of the following will have $pH > 7$?

a) $CH_3COOH + CH_3COONa$ b) $HCOOH + HCOOK$

c) CH_3COONH_4 d) $NH_4OH + NH_4Cl$

68. Assuming H_2SO_4 to be completely ionized the pH of a 0.05 M aqueous solution of sulphuric acid is approximately

a) 0.01 b) 0.005 c) 2 d) 1

69. In the third group of qualitative analysis, the precipatitating reagent is NH_4Cl/NH_4OH. The function of NH_4Cl is to

a) Increase the ionization of NH_4OH

b) Suppress the ionization of NH_4OH

c) Convert the ions of group third into their respective chlorides

d) Stabilise the hydroxides of group III cations

70. Of the given anions, the strongest Bronsted base is

a) $ClO^{\ominus}$ b) $ClO_2^{\ominus}$ c) $ClO_3^{\ominus}$ d) $ClO_4^{\ominus}$

71. A solution containing NH_4Cl and NH_4OH has $[\overset{\ominus}{O}H] = 10^{-6} mol\ L^{-1}$, which of the following hydroxides would be precipitated when this solution in added in equal volume to a solution containing 0.1 M of metal ions

a) $Mg(OH)_2, (K_{SP} = 3 \times 10^{-11})$ b) $Fe(Oh)_2\ (K_{sp} = 8 \times 10^{-16})$

c) $Cd(OH)_2(K_{sp} = 8 \times 10^{-6})$ d) $AgOH\ (K_{sp} = 5 \times 10^{-3})$

72. When the reaction. $2NO_2(g) \rightleftharpoons N_2O_4(g)$ reaches equilibrium at 298 K. The partial pressure of NO_2 and N_2O_4 are 0.2 KPa and 0.4 KPa, respectively. What is the equilibrium constant K_p of the above reaction at 298 K?

a) 0.1 b) 0.5 c) 1.0 d) 10

73. For a reaction $A(g) \rightleftharpoons B(g) + C(g)$. K_p at 400°C is 1.5×10^{-4} and K_p at 600°C is 6×10^{-3}. Which statement is incorrect?

a) The reaction is exothermic

b) Increase in temperature increases the formation of B

c) Increase in pressure increases the formation of A

d) Decrease in temperature and increase in pressure shift the equilibrium towards left

74. Which of the following solutions will have $pH = 10$ at 298 K?

a) 1×10^{-10} M HCl solution b) 1×10^{-4} M NaOH solution

c) 1×10^{-10} M NaOH solution d) Both (a) and (b)

75. pOH of water is 7.0 at 298 K. If water is heated to 350 K, which of the following should be true?

a) pOH will decrease

b) pOH will increase

c) pOH will remain seven

d) Concentration of $H^{\oplus}$ ions will increase but that of $\overset{\ominus}{OH}$ will decrease

76. A certain weak acid has a dissociation constant of 1.0×10^{-4}. The equilibrium constant for its reaction with a strong base is

a) 10×10^{-4} b) 10×10^{-10} c) 1.0×10^{10} d) 1.0×10^{14}

77. Which of the following factors will favour the reverse reaction in a chemical equilibrium?

a) Increase in concentration of one of the reactants

b) Increase in concentration of one of the products

c) Removal of one of the products regularly

d) None of these

78. Which of the following mixture solution has $\mathrm{pH} \approx 1.0$?
a) 100 mL M/10 HCl + 100 mL M/10 NaOH
b) 55 mL M/10 HCl + 45 mL M/10 NaOH
c) 10 mL M/10 HCl + 90 mL M/10 NaOH
d) 75 mL M/5 HCl + 25 mL M/5 NaOH

79. K_a for the reaction:
$Fe^{3+}(aq) + H_2O(l) \rightleftharpoons Fe(OH)^{2+}(aq) + H_3O^{\oplus}(aq)$ is 6.5×10^{-3}, what is the maximum pH value which could be used so that at least 80% of the total iron (III) in a dilute solution exists as Fe^{3+}
a) 2.0 b) ~ 2.4 c) ~ 2.8 d) ~ 1.6

80. How many grams of NaOH must be dissolved in $1\ L^{-1}$ of the solution to give it a pH value of 12?
a) $0.20\ g\ L^{-1}$ b) $0.40\ g\ L^{-1}$ c) $0.10\ g\ L^{-1}$ d) $1.2\ g\ L^{-1}$

81. $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$ in closed container at equilibrium. What would be the effect of addition of $CaCO_3$ on the equilibrium concentration of CO_2
a) Increases b) Decreases c) Data is not sufficient d) Remains unaffected

82. In Haber process, 30 L of dihydrogen and 30 L of dinitrogen were taken for reaction which yielded only 50% of the expected product. What will be the composition of gaseous mixture under the aforesaid condition in the end?
a) 10 L NH_3, 25 L N_2, 15 L H_2 b) 20 L NH_3, 20 L N_2, 20 L H_2
c) 20 L NH_3, 25 L N_2, 15 L H_2 d) 20 L NH_3, 10 L N_2, 30 L H_2

83. At what pH will a 10^{-3} M solution of indicator with $K_b = 10^{-10}$ changes colour?
a) 10 b) 4.0 c) 3 d) 7

84. The equilibrium constant of a reaction is 300, if the volume of the reaction flask is tripled, the equilibrium constant will be
a) 100 b) 300 c) 250 d) 150

85. For a reaction: $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ at certain temperature, the value of equilibrium constant is 50. If the volume of the vessel is reduced to half of its original volume, the value of new equilibrium constant will be
a) 25 b) 50 c) 100 d) Unpredictable

86. The solubility products of MA, MB, MC, and MD are 1.8×10^{-10}, 4×10^{-8} and 6×10^{-5} respectively. If a 0.01 M solution of MX is added dropwise to a mixture containing $A^{\ominus}$, $B^{\ominus}$, $C^{\ominus}$ and $D^{\ominus}$ ions, then the one to be precipitated first will be
a) MA b) MB c) MC d) MD

87. The K_a values of $CaCO_3$ and CaC_2O_4 in water are 4.7×1^{-9} and 1.3×10^{-9}, respectively, at 25°C. If a mixture of two is washed with H_2O, what is Ca^{2+} ion concentration in water?
a) 7.746×10^{-5} b) 5.831×10^{-5} c) 6.856×10^{-5} d) 3.606×10^{-5}

88. At a certain temperature the value of pK_w is 13.4 and the measured pH of soln is 7. The solution is
a) Acidic b) Basic c) Neutral d) Unpredictable

89. If $H^{\oplus}$ ion concentration of a solution is increased by 10 times, its pH will
a) Increase by 1 b) Remains unchanged c) Decreases by 1 d) Increase by 10

90. The vapour density of a mixture consisting of NO_2 and N_2O_4 is 38.3 at 275 K. The number of moles of NO_2 in the mixture:
a) 0.2 b) 0.4 c) 0.8 d) 1.6

91. One mole of SO_3 was placed in a litre reaction flask at a given temperature when the reaction equilibrium was established in the reaction
$2SO_3 \rightleftharpoons 2SO_2 + O_2$, the vessel was found to contain 0.6 mol of SO_2. The value of the equilibrium constant is
a) 0.36 b) 0.675 c) 0.45 d) 0.54

92. The pH of 10^{-5} M HCl solution if 1 ml of it is diluted to 1000 ml is:
a) 5 b) 8 c) 7.02 d) 6.98

93. For the reaction $N_2O_4(g) \rightleftharpoons 2NO_2(g)$, the degree of dissociation at equilibrium is 0.2 at 1 atm pressure. The equilibrium constant K_p will be
a) 1/2 b) 1/4 c) 1/6 d) 1/8

94. Some chemist at ISRO wished to prepared a saturated solution of a silver compound and they wanted it to have the highest concentration of silver ion possible. Which of the following compounds would they use?
K_{sp} (AgCl) $= 1.8 \times 10^{-10}, K_{sp}$(AgBr) $= 5.0 \times 10^{-13}$,
$K_{\text{sp}}(Ag_2CrO_4) = 2.4 \times 10^{-12}$ [Use $\sqrt[3]{0.6} = 0.84$]

a) AgCl
b) AgBr
c) Ag_2CrO_4
d) All of these

95. A salt X is dissolved in water having pH = 7. The resulting solution has a pH more than 7. The salt is made by neutralization of

a) A strong acid and strong base
b) A strong acid and strong weak base
c) A weak acid and weak base
d) A weak acid and strong base

96. Three sparingly soluble salts M_2X, MX, and MX_3 have the same solubility product. Their solubilities will be in the order

a) $MX_3 > MX > M_2X$
b) $MX_3 > M_2X > MX$
c) $MX > MX_3 > M_2X$
d) $MX > M_2X > MX_3$

97. For a sparingly soluble salt A_pB_q, the relationship of its solubility product (L_S) with its solubility (S) is

a) $L_S = S^{p+q}\, p^p\, q^q$
b) $L_S = S^{p+q}\, p^q\, q^p$
c) $L_S = S^{pq}\, p^p\, q^q$
d) $L_S = S^{pq}\, (pq)^{(p+q)}$

98. Let the solubilities of AgCl in H_2O, and 0.01 M $CaCl_2$, 0.01 M NaCl, and 0.05 M $AgNO_3$ be S_1, S_2, S_3, S_4, respectively. What is the correct relationship between these quantities

a) $S_2 > S_2 > S_3 > S_4$
b) $S_1 > S_2 = S_3 > S_4$
c) $S_1 > S_3 > S_2 > S_4$
d) $S_4 > S_2 > S_3 > S_1$

99. At 90°C, pure water has $[H_3O^{\oplus}]$ as 10^{-6} mol L^{-1}. What is the value of K_w at 90°C?

a) 10^{-6}
b) 10^{-12}
c) 10^{-14}
d) 10^{-8}

100. What concentration of CO_2 be in equilibrium with 0.025 M CO at 120°C for the reaction
$FeO(s) + CO(g) \rightleftharpoons Fe(s) + CO_2(g)$
If the value of $K_c = 5.0$?

a) 0.125 M
b) 0.0125 M
c) 1.25 M
d) 12.5 M

101. In a chemical reaction
$N_2 + 3H_2 \rightleftharpoons 2NH_3$, at equilibrium point

a) Equal volumes of N_2 and H_2 are reacting
b) Equal masses of N_2 and H_2, are reacting
c) The reaction has stopped
d) The same amount of ammonia is formed as is decomposed into N_2 and H_2

102. In the gaseous equilibrium
$A + 2B \rightleftharpoons C +$ Heat, the forward reaction is favoured:

a) Low P, High T
b) Low P, Low T
c) High P, Low T
d) High P, High T

103. The equilibrium constant in a reversible reaction at a given temperature which

a) Depends on initial concentration, of the reactants
b) Depends on the concentration of the products at equilibrium
c) Does not depend on the initial concentration
d) It is not characteristic of the reaction

104. 2.5 mL of $\frac{2}{5}$ M weak monoacidic base ($K_b = 1 \times 10^{-12}$ at 25°C) is titrated with $\frac{2}{15}$ M HCl in water at 25°C. The concentration of H^+ at equivalence point is
($K_w = 1 \times 10^{-14}$ at 25°C)

a) 3.7×10^{-13} M
b) 3.2×10^{-7} M
c) 3.2×10^{-2} M
d) 2.7×10^{-2} M

105. One mole of $N_2O_4(g)$ at 300 K is kept in a closed container under 1 atm. It is heated to 600 K when 20% by mass of $N_2O_4(g)$ decomposes to $NO_2(g)$. The resultant pressure is

a) 1.2 atm
b) 2.4 atm
c) 2.0 atm
d) 1.0 atm

106. The equilibrium constant K for the reaction $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$ at room temperature is 2.85 and that at 698 K is 1.4×10^{-2}. This implies

a) HI is exothermic compound
b) HI is very stable at room temperature

c) HI is relatively less stable than H_2 and I_2 d) HI is resonance stabilised

107. When equal volumes of the following solutions are mixed, the precipitation of AgCl ($K_{sp} = 1.8 \times 10^{-10}$) will occur only with
a) 10^{-4} M ($Ag^{\oplus}$) and 10^{-4} M ($Cl^{\ominus}$) b) 10^{-5} M ($Ag^{\oplus}$) and 10^{-5} M ($Cl^{\ominus}$)
c) 10^{-6} M ($Ag^{\oplus}$) and 10^{-6} M ($Cl^{\ominus}$) d) 10^{-10} M ($Ag^{\oplus}$) and 10^{-10} M ($Cl^{\ominus}$)

108. Which of the following solutions will have pH close to 1.0?
a) 100 mL of (M/10) HCl + 100 mL of (M/10) NaOH
b) 55 mL of (M/10) HCl + 45 mL of (M/10) NaOH
c) 10 mL of (M/10) HCl + 90 mL of (M/10) NaOH
d) 75 mL of (M/5) HCl + 25 mL of (M/5) NaOH

109. Which one of the following salts when dissolves in water hydrolyse?
a) NaCl b) NH_4Cl c) KCl d) Na_2SO_4

110. Which of the following is a Lewis base?
a) H_2O b) $Cl^{\ominus}$ c) BF_3 d) NH_3

111. When two reactants A and B are mixed to give products C and D, the reaction quotient Q at the initial stages of the action
a) Is zero b) Decreases with time
c) Is independent of time d) Increases with time

112. Amongst the following, the total number of compounds whose aqueous solution turns red litmus paper blue is
KCN K_2SO_4 $(NH_4)_2C_2O_4$ NaCl
$Zn(NO_3)_2$ $FeCl_3$ K_2CO_3 NH_4NO_3
LiCN
a) 1 b) 2 c) 3 d) 4

113. Which of the following salt undergoes hydrolysis?
a) CH_3COOK b) $NaNO_3$ c) KCl d) K_2SO_4

114. The solubility of AgI in NaI solutions is less than that in pure water because:
a) AgI forms complex with NaI
b) Of common ion effect
c) Solubility product of AgI is less than that of NaI
d) The temperature of the solution decreases

115. When two reactants A and B are mixed to give products C and D, the reaction quotient (Q) at the initial stages of the reaction
a) Is zero b) Decreases with time
c) Is independent of time d) Increases with time

116. Among the following hydroxides, the one which has the lowest value of K_{sp} at ordinary temperature (about 25°C) is
a) $Mg(OH)_2$ b) $Ca(OH)_2$ c) $Ba(OH)_2$ d) $Be(OH)_2$

117. An aqueous solution of HCl is 10^{-9} M HCl. The pH of the solution should be
a) 9 b) Between 6 and 7 c) 7 d) Unpredictable

118. Which of the following sill suppress the ionization of acetic acid in aqueous solution?
a) NaCl b) HCl c) KCl d) Upredicatble

119. 1 mol of XY(g) and 0.2 mol of Y(g) are mixed in 1 L vessel. At equilibrium, 0.6 mol of Y(g) is present. The value of K for the reaction
$XY(g) \rightleftharpoons X(g) + Y(g)$ is
a) 0.04 mol L^{-1} b) 0.06 mol L^{-1} c) 0.36 mol L^{-1} d) 0.40 mol L^{-1}

120. For the chemical reaction
$3X(g) + Y(g) \rightleftharpoons X_3Y(g)$,
the amount of X_3Y at equilibrium is affected by

a) Temperature and pressure b) Temperature only
c) Pressure only d) Temperature, pressure, and catalyst

121. At 90°C, pure water has $[H_3O^{\oplus}] = 10^{-6.7}$ mol L^{-1}. What is the value of K_w at 90°C?
a) 10^{-6} b) 10^{-12} c) $10^{-13.4}$ d) $10^{-6.7}$

122. Of the given anions, the strongest Bronsted base is
a) $ClO^{\ominus}$ b) $ClO_2^{\ominus}$ c) $ClO_3^{\ominus}$ d) $ClO_4^{\ominus}$

123. The equilibrium constant for the reaction $w + x \rightleftharpoons y + z$ is 9. If one mole of each of w and x are mixed and there is no change in volume, the number of moles of y for formed is
a) 0.10 b) 0.50 c) 0.75 d) 0.54

124. A 0.1 molar solution of weak base BOH is 1% dissociated. If 0.2 mol of BCl is added in 1 L solution of BOH. The degree of dissociation of BOH will become
a) 0.02
b) 0.005
c) 5×10^{-5}
d) 2×10^{-3}

125. What would be the solubility of silver chloride in 0.10 M NaCl solution?
K_{sp} for AgCl $= 1.20 \times 10^{-10}$
a) 0.1 M b) 1.2×10^{-6} M c) 1.2×10^{-9} M d) 1.2×10^{-10} M

126. Which one of following will have the largest pH?
a) Solution containing 1×10^{-2} mol of K_2SO_4 L^{-1}
b) Pure water
c) Solution containing 1.0×10^{-2} mol of HCl L^{-1}
d) Solution containing 1×10^{-2} mol of NH_4OH L^{-1}

127. 20 cm^3 of x M solution of HCl is exactly neutralized by 40 cm^3 of 0.05 M NaOH solution, the pH of HCl solution is
a) 1.0 b) 2 c) 1.5 d) 2.5

128. 4 moles of A are mixed with 4 moles of B, when 2 moles of C are formed at equilibrium according to the reaction $A + B \rightleftharpoons C + D$
The value of equilibrium constant is
a) 4 b) 1 c) 1/2 d) 1/4

129. The pK_b of $CN^{\ominus}$ is 4.7. The pH of solution prepared by mixing 2.5 mol of KCN of 2.5 mol of HCN in water and making the total volume upto 500 mL is
a) 10.3 b) 9.3 c) 8.3 d) 4.7

130. XY_2 dissociates $XY_2\,(g) \rightleftharpoons XY\,(g) + Y(g)$. When the initial pressure of XY_2 is 600 mm Hg, the total equilibrium pressure is 800 mm Hg. Calculate K for the reaction. Assuming that the volume of the system remains unchanged
a) 50.0 b) 100.0 c) 166.6 d) 400.0

131. A monoprotic acid (HA) is 1% ionized in its aqueous solution of 0.1 M strength. Its pOH will be
a) 11 b) 3 c) 10 d) 2

132. 4 mol of carbon dioxide was heated in 1 dm^3 vessel under conditions which produced at equilibrium 25% dissociation into carbon monoxide and oxygen. The number of moles
of carbon monoxide produced
a) 0.5 b) 1.0 c) 2.0 d) 4.0

133. 20 mL of M/10 CH_3COOH solution is titrated with M/10 NaOH solution. After addition of 16 mL solution of NaOH. What is the pH of the solution ($pK_a = 4.47$)
a) 5.05 b) 4.15 c) 4.75 d) 5.35

134. A solution with pH = 2 is more acidic then one with a pH = 6 by a factor of
a) 4 b) 12 c) 400 d) 10^4

135. What are the units in which the solubility product of $Ca_3(PO_4)_2$ is expressed?
a) mol dm^{-3} b) mol^2 dm^{-6} c) mol^3 dm^{-9} d) mol^5 dm^{-15}

136. Inert gas has been added to the following equilibrium system at constant volume

$SO_2(g) + 1/2O_2(g) \rightleftharpoons SO_3(g)$

To which direction will the equilibrium shift?

a) Forward b) Backward c) No effect d) Unpredictable

137. The best indicator for the detection of end point in titration of a weak acid and a strong base is

a) Methyl orange (3 to 4)
b) Methyl red (5 to 6)
c) Bromothymol blue (6 to 7.5)
d) Phenolphthalein (8 to 9.6)

138. In the problem number 21, the number of mole of N_2O_4 in 100 g of the mixture is:

a) 0.43 b) 0.86 c) 0.57 d) 0.2

139. Which of the following can act both as a Bronsted acid and a Bronsted base?

a) $O_2^{\ominus}$ b) HCl c) $HSO_4^{\ominus}$ d) Na_2CO_3

140. For the reactions $X \rightleftharpoons 2Y$ and $Z \rightleftharpoons P + Q$ occurring two different pressure P_1 and P_2, respectively. The ratio of the two pressures is 1: 3. What will be the ratio of equilibrium constant, if the degree of dissociation of X and Z are equal

a) 1: 36 b) 1: 12 c) 1: 9 d) 2: 3

141. An acid HA is 40% dissociated in an aqueous solution. The hydronium ion concentration of its 0.2 M solution would be

a) 0.08 M b) 0.4 M c) 0.2 M d) None

142. A solution of 0.1 M NaZ has pH = 8.90. The K_a of HZ is

a) 6.3×10^{-11} b) 6.3×10^{-10} c) 1.6×10^{-5} d) 1.6×10^{-6}

143. The equilibrium constant K for the reaction: $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$ at room temp is 2.85 and that at 698 K is 1.4×10^{-2}. This implies that the forward reaction is

a) Exothermic b) Endothermic c) Exergonic d) Unpredictable

144. pH of a solution made by mixing 50 mL of 0.2 M NH_4Cl and 75 mL of 0.1 M NaOH is [pK_a] of $NH_3(aq) = 4.74. \log 3 = 0.47$]

a) 7.02 b) 13.0 c) 7.02 d) 9.73

145. A certain buffer solution contains equal concentration of $X^{\ominus}$ and HX. The K_b for $X^{\ominus}$ is 10^{-10}. The pH of the buffer is

a) 4 b) 7 c) 10 d) 14

146. A solution of CaF_2 is found to contain 4×10^{-4} M of $F^{\ominus}$ ions. K_{sp} of CaF_2 is

a) 3.2×10^{-11} b) 0.8×10^{-11} c) 6.4×10^{-11} d) 32×10^{-11}

147. The solubility of solid silver chromate, $AgCrO_4$, is determined in three solvents K_{sp} of $AgCrO_4 = 9 \times 10^{-12}$

I. pure water II. 0.1 M $AgNO_3$
III. 0.1 M Na_2CrO_4

Predict the relative solubility of Ag_2CrO_4 in the three solvents

a) I = II = III b) I < II < III c) II = III < I d) II < III < I

148. Which of the following salts undergoes anionic hydrolysis?

a) $CuSO_4$ b) NH_4Cl c) $FeCl_3$ d) Na_2CO_3

149. For the reaction, $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$, the equilibrium constant K_p changes with

a) Total pressure b) Catalyst
c) The amounts of H_2 and I_2 present d) Temperature

150. Which of the following is mot soluble?

a) Bi_2S_3 ($K_{sp} = 1 \times 10^{-70}$) b) MnS ($K_{sp} = 7 \times 10^{-16}$)
c) CuS ($K_{sp} = 8 \times 10^{-37}$) d) Ag_2S ($K_{sp} = 6 \times 10^{-51}$)

151. At equilibrium $X + Y \rightleftharpoons 3Z$. 1 mol of X, 2 mol of Y and 4 mol of Z are contained in a 3-L vessel. Among the given values of reaction coefficient Q, given at three different instants, which value refers to system at equilibrium?

a) 10 b) 15 c) 10.67 d) 12

152. Buffer solutions can be prepared from mixtures of

a) HCl and NaCl b) NaH_2PO_4 and Na_2HPO_4

c) $CH_3COOH + NaCl$ d) $NH_4OH + NH_3$

153. The equilibrium constant for a reaction $A + 2B \rightleftharpoons 2C$ is 40. The equilibrium constant for reaction $C \rightleftharpoons B + 1/2\,A$ is

a) 1/ 40 b) $(1/40)^{1/2}$ c) $(1/40)^2$ d) 40

154. A saturated solution of Ag_2SO_4 is 2.5×10^{-2} M. The value of its solubility product is

a) 62.5×10^{-6} b) 6.25×10^{-4} c) 15.625×10^{-10} d) 3.125×10^{-6}

155. M_2SO_4 ($M^{\oplus}$ is a monovalent metal ion) has a K_{sp} of 3.2×10^{-5} at 298 K. The maximum concentration of ${SO_4}^{2-}$ ion that could be attained in a saturated solution of this solid at 298 K is

a) 3×10^{-3} M b) 7×10^{-2} M c) 2.89×10^{-4} M d) 2×10^{-2} M

156. The compound that is not a Lewis acid is

a) BF_3 b) $AlCl_3$ c) $BeCl_2$ d) $SnCl_4$

157. The pH value of 0.001 M aqueous solution of NaCl is

a) 7 b) 4 c) 11 d) Unpredictable

158. A definite volume of a N/20 CH_3COOH ($pK_a = 4.7447$) is titrated with a strong base (NaOH). It is found that 80 equal sized drops of NaOH, added from a burette effects the complete neutralization. Find the pH, when the acid soln is neutralized to the extent of 20%

a) 4.14 b) 9.86 c) 5.34 d) 8.68

159. $CaCO_3$ and $BaCO_3$ have solubility product values 1×10^{-8} and 5×10^{-9}, respectively. If water is shaken up with both solids till equilibrium is reached, the concentration of ${CO_3}^{2-}$ ion is

a) 1.5×10^{-8} b) 1.225×10^{-4} c) 2.25×1^{-9} d) None of theses

160. For the reaction

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

The equilibrium constant K_p changes with

a) Total pressure b) Catalyst

c) The amounts of H_2 and I_2 present d) Temperature

161. One of the following is a Bronsted acid but not a Bronsted base:

a) H_2S b) H_2O c) ${HCO_3}^{\ominus}$ d) NH_3

162. When equal volumes of the following solution are mixed, precipitation of AgCl ($K_{sp} = 1.8 \times 10^{-10}$) will occur only with

a) 10^{-4} M($Ag^{\oplus}$) and 10^{-4} M ($Cl^{\ominus}$) b) 10^{-5} M($Ag^{\oplus}$) and 10^{-5} M ($Cl^{\ominus}$)

c) 10^{-5} M($Ag^{\oplus}$) and 10^{-6} M ($Cl^{\ominus}$) d) 10^{-4} M($Ag^{\oplus}$) and 10^{-10} M ($Cl^{\ominus}$)

163. pH of an aqueous solution of 0.6 M NH_3 and 0.4 M NH_4Cl is 9.4 ($pK_b = 4.74$). The new pH when 0.1 M $Ca(OH)_2$ solution is added to it

a) 9.86 b) 10.14 c) 10.2 d) 10.86

164. 20 mL of 0.1 N HCl is mixed with 20 mL of 0.1 N KOH. The pH of the solution would be

a) 0 b) 7 c) 2 d) 9

165. An aqueous solution of aluminium sulphate would show

a) Acidic b) Neutral

c) Basic d) Both acidic and basic reaction

166. The active mass of 64 g of HI in a 2-L flask would be

a) 2 b) 1 c) 5 d) 0.25

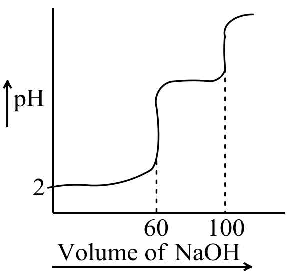
167. The pH of a 0.1 M solution of NH_4OH (having dissociation constant $K_b = 1.0 \times 10^{-5}$) is equal to

a) 10 b) 6 c) 11 d) 12

168. Which of the following is not a Lewis base?

a) $CN^{\ominus}$ b) ROH c) NH_3 d) $AlCl_3$

169. The following graph represents the titration of pH vs volume



a) A diprotic acid
b) Two monoprotic acids with the same K_a but different concentrations
c) Two monoprotic acids with different K_a but the same concentration
d) Two monoprotic acids with different K_a and different concentrations

170. A solution has pOH equal to 13 at 298 K. The solution will be
a) Highly acidic b) Highly basic c) Moderately basic d) Unpredictable

171. An aqueous solution of metal chloride MCl_2(0.05 M) is saturated with H_2S (0.1 M). The minimum pH at which metal sulphide will be precipitated is
$[K_{sp}\ MS = 5 \times 10^{-21}, K_1\ (H_2S) = 10^{-7}, K_2(H_2S) = 10^{-14}$
a) 3.25 b) 2.50 c) 1.50 d) 1.25

172. The equilibrium constant K_p for a homogeneous gaseous reaction is 10^{-8}. The standard Gibbs free energy change $\Delta G^{\ominus}$ for the reaction (using $R = 2\ \text{cal}\ K^{-1}\ \text{mol}^{-1}$) is
a) 10.98 kcal b) $-$ 1.8 kcal c) $-$ 4.1454 kcal d) +4.1454 kcal

173. When 2 mol of HCl is added to 1 L of an acidic buffer, its pH changes from 3.4 to 2.9. The buffer capacity of the buffer solution is
a) 2 b) 0 c) 4 d) 8

174. 8 mol of a gas AB_3 are introduced into a 1.0 dm^3 vessel. It dissociates as
$2AB_3(g) \rightleftharpoons A_2(g) + 3B_2(g)$
At equilibrium, 2 mol of A_2 is found to be present. The equilibrium constant for the reaction is
a) 2 $mol^2\ L^{-2}$ b) 3 $mol^2\ L^{-2}$ c) 27 $mol^2\ L^{-2}$ d) 36 $mol^2\ L^{-2}$

175. The best indicator for the detection of the end point in the titration of a weak acid and a strong base is
a) Methyl orange (pH range 3 to 4) b) Methyl red (pH range 4 to 6)
c) Thymol blue (pH range 8 to 3) d) Phenolphthalein (pH range 8 to 10)

176. An example of a reversible reaction is
a) $Pb(NO_3)_2(aq) + 2NaI(aq) \rightarrow PbI_2(s) + 2NaNO_3(aq)$
b) $AgNO_3(aq) + HCl(aq) \rightarrow AgCl(s) + HNO_3(aq)$
c) $2Na(s) + H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$
d) $KNO_3(aq) + NaCl(aq) \rightarrow KCl(aq) + NaNO_3(aq)$

177. Which of the following is the strongest acid?
a) $ClO_3(OH)$ b) $ClO_2(OH)$ c) $SO(OH)_2$ d) $SO_2(OH)_2$

178. The ionization constant of an acid base indicator (a warak acid) is 1.0×10^{-6}. The ionized form of the indicator is red and unionized form is blue. The pH change required to alter the colour of indicator from 80% red is
a) 0.80 b) 1.20 c) 1.40 d) 2.00

179. The pH of 0.1 M solution of the following salts increases in the order
a) $NaCl < NH_4Cl < NaCN < HCl$ b) $HCl < NH_4Cl < NaCl < NaCN$
c) $NaCN < NH_4Cl < NaCl < HCl$ d) $HCl < NaCl < NaCN < NH_4Cl$

180. What is the solubility of $PbSO_4$ in 0.01 M Na_2SO_4 solution if K_{sp} for $PbSO_4 = 1.25 \times 10^{-9}$?
a) $1.25 \times 10^{-7}\ mol\ L^{-1}$ b) $1.25 \times 10^{-9}\ mol\ L^{-1}$ c) $1.25 \times 10^{-10}\ mol\ L^{-1}$ d) $0.10\ mol\ L^{-1}$

181. $Ag^+ + NH_3 \rightleftharpoons [Ag(NH_3)]^+;\ K_1 = 3.5 \times 10^{-3}$
$[Ag(NH_3)]^+ + NH_3 \rightleftharpoons [Ag(NH_3)_2]^+;$
$K_2 = 1.7 \times 10^{-3}$

Then the formation constant of $[Ag(NH_3)_2]^+$ is

a) 6.08×10^{-6} b) 6.08×10^{6} c) 6.08×10^{-9} d) None of these

182. Which one is not an acid salt?

a) NaH_2PO_4 b) NaH_2PO_2
c) NaH_2PO_3 d) All of the above are acid salts

183. For the equilibrium system

$2HX(g) \rightleftharpoons H_2(g) + X_2(g)$
the equilibrium constant is 1.0×10^{-5}. What is the concentration of HX if the equilibrium concentration of H_2 and X_2 are 1.2×10^{-3} M, and 1.2×10^{-4} M respectively?

a) 12×10^{-4} M b) 12×10^{-3} M c) 12×10^{-2} M d) 12×10^{-1}M

184. Conjugate base of $\overset{\ominus}{O}H$ is

a) H_2O b) $H_3O^{\oplus}$ c) $H^{\oplus}$ d) O^{2-}

185. The solubility of CO_2 in water increases with

a) Increase in temperature b) Reduction of gas pressure
c) Increase in gas pressure d) Increase in volume

186. Out of the following the compound whose water solution has the highest pH is

a) NaCl b) Na_2CO_3 c) NH_4Cl d) $NaHCO_3$

187. If $K_{sp}(PbSO_4) = 1.8 \times 10^{-8}$ and $K_a(HSO_4^{\ominus}) = 1.0 \times 10^{-2}$ the equilibrium constant for the reaction
$PbSO_4(s) + H^{\oplus}(aq) \rightleftharpoons HSO_4^{\ominus}(aq) + Pb^{2+}(aq)$ is

a) 1.8×10^{-6} b) 1.8×10^{-10} c) 2.8×10^{-10} d) 1.0×10^{-2}

188. The aqueous solution of $AlCl_3$ is acidic due to

a) Cation hydrolysis b) Anion hydrolysis
c) Hydrolysis of both anion and cation d) Dissociation

189. When solid KCl is added to a saturated solution of AgCl in H_2O

a) Nothing happens b) Solubility of AgCl decreases
c) Solubility of AgCl increases d) Solubility product of AgCl increases

190. When 20 mL of M/20 NaOH is added to 10 mL of M/10 HCl, the resulting solution will

a) Turn blue litmus red
b) Turn phenolphthalein solution pink
c) Turns methyl orange red
d) Will have no effect on either red or blue litmus

191. When 0.002 mol of acid is added to 250 mL of a buffer solution, pH decreases by 0.02 units. The buffer capacity of the system is

a) 0.1 b) 0.2 c) 0.3 d) 0.4

192. For the indicator the ratio $\frac{[Ind^{\ominus}]}{[HIn]}$ is 7.0 at pH of 4.3. K_{eq} for the indicator ius

a) 3.5×10^{-4} b) 3.5×10^{-5} c) 3.5×10^{-2} d) 3.5×10^{-3}

193. For a hypothetical reaction of the kind

$$AB_2(g) + \frac{1}{2} B_2(g) \rightleftharpoons AB_3(g);\ \Delta H = -x \text{ kJ}$$

More AB_3 could be produced at equilibrium by

a) Using a catalyst b) Removing some of B_2
c) Increasing the temperature d) increasing the pressure

194. The equilibrium constant for a reaction
$N_2(g) + O_2(g) = 2NO(g)$ is 4×10^{-4} at 2000 K. In the presence of catalyst, the equilibrium constant is attained 10 times faster. The equilibrium constant in the presence of catalyst, at 2000 K is

a) 40×10^{-4} b) 4×10^{-4} c) 40×10^{-2} d) Incomplete data

195. The pH of solution 7.00. To this solution, sufficient base is added to increase the pH to 12.0. The increase in $\overset{\ominus}{O}H$ ion concentration is

a) 5 times   b) 1000 times   c) 10^5 times   d) 4 times

196. A solution contains 10 mL of 0.1 N NaOH and 10 mL of 0.05 Na_2SO_4. pH of this solution is
a) 7   b) Less than 7   c) Greater than 7   d) Zero

197. 0.1 M solution of which of the substances will behave basic?
a) Sodium borate   b) Ammonium ditoride   c) Calcium nitrate   d) Sodium sulphate

198. In a chemical reaction, equilibrium is said to have been established when the
a) Concentration of reactants and products are equal
b) Opposing reaction ceases
c) Velocities of opposing reaction become equal
d) Temperature of opposing reaction are equal

199. The pink colour of phenolphthalein in alkaline medium is due to
a) $\overset{\ominus}{\mathrm{O}}\mathrm{H}$ ions   b) Positive ions   c) Negative ion   d) Neutral form

200. A certain buffer solution contains equal concentration of and $X^{\ominus}$ and HX. The K_b for $X^{\ominus}$ is 10^{-10}. The pH of the buffer is
a) 4   b) 7   c) 10   d) 14

201. 100 mL of a buffer solution contains 1.0 M each of weak acid HA and salt NaA. How many gram of NaOH should be added to the buffer so that it pH will be 6?
(K_a of HA $= 10^{-5}$)
a) 0.328   b) 0458   c) 4.19   d) None

202. At constant temperature, the equilibrium constant (K_p) for the decomposition reaction
$N_2O_4 \rightleftharpoons 2NO_2$
is expressed by $K_p = 4x^2\, p/(1 - x^2)$, where $p =$ pressure $x =$ extent of decomposition. Which of the following statements is true?
a) K_p increases with increase in p b) K_p increases with increase in x
c) K_p increases with decrease in x d) K_p remains constant with change in p and x

203. A weak acid HX has the dissociation constant 1×10^{-5} M. It forms a salt NaX on reaction with alkali. The percentage hydrolysis of 0.1 M solutions of NaX is
a) 0.0001%   b) 0.01%   c) 0.1%   d) 0.15%

204. K_1 and K_2 are equilibrium constants for reaction (i) and (ii)
$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ ...(i)
$NO(g) \rightleftharpoons 1/2N_2(g) + 1/2O_2(g)$ ...(ii)
Then,
a) $K_1 = (1/K_2)^2$ b) $K_1 = {K_2}^2$ c) $K_1 = 1/K_2$ d) $K_1 = (K_2)^{\circ}$

205. Which of the following when mixed, will give a solution with pH > 7
a) 0.1 M HCl + 0.2 M NaCl
b) 100 mL of 0.2 M H_2SO_4 + 100 mL of 0.3 M NaOH
c) 100 mL of 0.1 M $HC_2H_3O_2$ + 100 mL of 0.1 M KOH
d) 25 mLof 0.1 HNO_3 + 25 mL of 0.1 M NH_3

206. An acidic buffer solution can be prepared by mixing the solution of
a) Sodium acetate and acetic acid
b) Ammonium chloride and ammonium hydroxide
c) Sulphuric acid and sodium sulphate
d) Sodium chloride and sodium hydroxide

207. The pH of 10^{-8} M solution of HCl in water is
a) 8   b) −8   c) Between 7 and 8   d) Between 6 and 7

208. The system $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ attains equilibrium. If the equilibrium concentration of $PCl_3(g)$ is doubled, the concentration of $Cl_2(g)$ would become
a) 1/4 its original value   b) 1/2 its original value
c) Twice its original value   d) Unpredictable

209. A solution is saturated with respect to $SrCO_3$ and SrF_2. The $[CO_3^{2-}]$ was found to be 1.2×10^{-3} M. The concentration of $F^{\ominus}$ in the solution would be

Given K_{sp} of $SrCO_3 = 7.0 \times 10^{-10}\ M^2, K_{sp}$ of $SrF_2 = 7.9 \times 10^{-10}\ M^3$

a) 1.3×10^{-3} M b) 2.6×10^{-2} M c) 3.7×10^{-2} M d) 5.8×10^{-7} M

210. The precipitate of $CaF_2 (K_{sp} = 1.7 \times 10^{-10})$ is obtained when equal volumes of the following are mixed

a) 10^{-4} M $Ca^{2+} + 10^{-4}$ M $F^{\ominus}$ b) 10^{-2} M $Ca^{2+} + 10^{-3}$ M $F^{\ominus}$

c) 10^{-5} M $Ca^{2+} + 10^{-3}$ M $F^{\ominus}$ d) 10^{-3} M $Ca^{2+} + 10^{-5}$ M $F^{\ominus}$

211. For $N_2 + 3H_2 \rightleftharpoons 2NH_3 + \text{Heat}$

a) $K_p = K_c$ b) $K_p = K_c RT$ c) $K_p = K_c(RT)^{-2}$ d) $K_p = K_c(RT)^{-1}$

212. According to le-Chatelier's principle, adding heat to a solid and liquid in equilibrium will cause the

a) Amount of solid to decrease b) Amount of liquid to decrease

c) Temperature to rise d) Temperature to fall

213. For the chemical reaction

$3X(g) + Y(g) \rightleftharpoons X_3Y(g)$

The amount of X_3Y at equilibrium is affected by

a) Temperature and pressure b) Temperature only

c) Pressure only d) Temperature, pressure, and catalyst

Multiple Correct Answers Type

214. The pH of 0.1 M solution of the following salts increases in the order

a) $NaCl < NH_4Cl < NaCN < HCl$ b) $HCl < NH_4Cl < NaCl < NaCN$

c) $NaCN < NH_4Cl < NaCl < HCl$ d) $HCl < NaCl < NaCN < NH_4Cl$

215. Which statements in part(c)

a) Compared to a strong acid, a, weak acid titration with base starts at a higher pH

b) Compared to a strong base, a weak base titration ends at a lower pH

c) In both (a) and (b) titration curve is shortened at each end

d) For titration of a weak acid and a weak base, the nearly vertical portion of the curve would be insufficient for an effective titration

216. Which of the following salt's solutions is/are acidic?

a) NaOCl b) NH_4NO_3 c) $NaHSO_3$ d) $FeCl_3$

217. 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) Increasing the volume of the container

218. The Ostwald's dilution law:

a) Is valid for weak electrolyte dissociation

b) Is useful in calculating ionization constant of acids or bases

c) Fails completely when applied to strong electrolytes

d) None of the above

219. Which of the following statement(s) is/are wrong?

a) pH of the human blood is 7.2 and it is alkaline

b) pH of buffers in stomach is acidic range

c) pH of buffers in intestine is in alkaline range

d) pH of H_2O is 6.5 at 60°C and thus, acidic

220. Which of the following will change if a 0.1 M solution of a weak acid is diluted to 0.01 M at constant

temperature?
a) K_a
b) pH
c) H^+ ion concentration
d) Ionization percentage

221. A solution of 0.01 M Fe^{2+} in a saturated H_2S solution and (i) 0.2 M of $H^{\oplus}$ (ii) 0.001 M of $H^{\oplus}$. ($K_1 \times K_2$ of $H_2S = 10^{-21}, K_{sp}FeS = 3.7 \times 10^{-19}$)
Which of the following statement is/are correct
a) FeS will precipitate in solution (i)
b) FeS will not precipitate in solution (i)
c) FeS will precipitate in solution (ii)
d) FeS will not precipitate in solution (ii)

222. Which among the following qualifies as a Lewis acid?
a) NaF b) NaCl c) BF_3 d) $MgCl_2$

223. Which of the following will qualify as Lewis base?
a) BCl_3 b) CH_4 c) PH_3 d) NH_3

224. An acid is a substance which:
a) Accepts a lone pair of electron (Lewis concept)
b) Donates a proton (Lowry and Bronsted concept)
c) Acts as an acid only in presence of base
d) None of the above

225. Which of the following are true for an acid-base titration?
a) Indicators catalyst the acid-base reactions by relasing or accepting $H^{\oplus}$ 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 the absence of indicators
d) Indicators have different colours in dissociated and undissociated forms

226. Which of the following statements is/are true?
a) The solubility product is the product of concentration of ions of an electrolyte each raised to the power of its coefficient in the balanced chemical equation in a saturated solution
b) The solubility product of an electrolyte is a function of temperature
c) Cations of group III are precipitated as their hydroxides by NH_4OH in the presence of NH_4Cl because the solubility products of these hydroxides are low
d) The ionic product changes with the concentration of an electrolyte

227. Chemical equilibrium for a reversible change means for :
a) The forward reaction proceeds as fast as the backward reaction, i.e., velocity of opposing reaction are equal
b) No change in conc. of reaction species with time
c) Dynamic equilibrium
d) None of the above

228. Which of the following is/are not correct?
a) K_w is always constant and equal to 10^{-14}
b) $pH + pOH = pK_w$ at all temperatures
c) Salts of weak acid ad weak base do not undergo hydrolysis
d) Addition of sodium acetate to acetic acid increases the pH of acetic acid

229. A process will be irreversible when one or more of the product separate out as :
a) Insoluble
b) Volatile species
c) Solid
d) None of these

230. A reaction mixture containing 0.050 atm N_2, 3.0 atm H_2, and 0.050 atm NH_3 is heated to 450°C. The value

of K_p is 4.28×10^{-5} atm^{-2}

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

The correct statement (s) is/are

a) Reaction goes towards the left
b) Reaction goes towards the right
c) N_2 and H_2 combine to form ammonia
d) Ammonia gas decomposes into H_2 and N_2

231. The phenomenon of interaction of anions and cations furnished by a electrolyte with the H^+ and OH^- ions of water to produce acidic nature or alkaline nature is known as hydrolysis. In hydrolysis:

a) The pH may be either increase or decrease
b) All the salts (except those made up with strong anion and cation) undergo hydrolysis
c) The variation of pH depends upon the nature of salt as well as on the temperature
d) None of these

232. The rate of disappearance of A at two temperature is given by $A \rightleftharpoons B$

i) $\frac{-d[A]}{dt} = 2 \times 10^{-2}[A] - 4 \times 10^{-3}[B]$ at 300 K

ii) $\frac{-d[A]}{dt} = 4 \times 10^{-2}[A] - 16 \times 10^{-4}[B]$ at 400 K

From the given values of heat of reaction which are incorrect

a) 3.86 kcal
b) 6.93 kcal
c) 1.68 kcal
d) 1.68×10^{-2} kcal

233. Which of the following is/are example(s) of autoprotolysis?

a) $NH_3 + NH_3 \rightleftharpoons NH_4^+ + NH_2^-$
b) $CH_3OH + CH_3OH \rightleftharpoons CH_3OH_2^+ + CH_3O^-$
c) $HCOOH + HCOOH \rightleftharpoons HCOOH_2^+ + HCOO^-$
d) $HCl + HF \rightleftharpoons H_2Cl^- + F^-$

234. An acid-base indicator has $K_a = 3.0 \times 10^{-5}$. The acid form of the indicator is red and the basic form is blue. Then:

a) pH is 4.04 when indicator is 75% red
b) pH is 5.00 when indicator is 75% blue
c) pH is 5.00 when indicator is 75% red
d) pH is 4.05 when indicator is 75% blue

235. A buffer solution can be prepared from a mixture of

a) Ammonia and ammonium chloride in water
b) Sodium acetate and acetic acid in water
c) Sodium acetate and hydrochloric acid in water
d) Ammonia and sodium hydroxide in water

236. For which of the following reactions at equilibrium at constant temperature, doubling the volume will cause a shift to the right?

a) $N_2O_4(g) \rightleftharpoons 2NO_2(g)$
b) $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$
c) $2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g)$
d) $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$

237. Which of the following is/are soft acid(s)?

a) Cu^+
b) NO_2^-
c) Na^+
d) Hg^{2+}

238. Which of the following is/are buffer solution(s)?

a) 10 mL 0.1 M HCl + 20 mL 0.2 M NaCN
b) $NH_4Cl + NH_4OH$
c) $NaOH + Na_2SO_4$
d) Borax + boric acid

239. In qualitative analysis of acid radicals, it is necessary to prepare sodium carbonate extract for the test of:

a) CH_3COO^-
b) NO_3^-
c) NO_2^-
d) Cl^-

240. $N_2O_2 \rightleftharpoons 2NO, K_1;$

$\left(\frac{1}{2}\right) N_2 + \left(\frac{1}{2}\right) O_2 \rightleftharpoons NO, K_2;$

$2NO \rightleftharpoons N_2 + O_2; K_3;$

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

Correct relation(s) between K_1, K_2, K_3, 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

241. Consider the reaction, $2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g) + \text{Heat}$. Under what conditions shift is underterminable?
   a) Increase in temperature and decrease in volume
   b) Addition of O_2 and decrease in volume
   c) Addition of CO and increase in temperature at constant volume
   d) Addition of CO and removal of CO_2 at constant volume
242. Which of the following will not affect the value of equilibrium constant of a reaction?
   a) Change in the concentration of the reactants
   b) Change in temperature
   c) Change in pressure
   d) Addition of catalyst
243. Which is/are conjugate acid-base pair(s)?
   a) HNO_2, NO_2^-
   b) H_3O^+, OH^-
   c) $CH_3NH_3^+, CH_3NH_2$
   d) H_2S, S^{2-}
244. 138 g of $N_2O_4(g)$ is placed in 8.2 L container at 300 K. The equilibrium vapour density of mixture was found to be 30.67. Then ($R = 0.082 \text{ L atm mol}^{-1}\text{K}^{-1}$)
   a) Total pressure at equilibrium = 6.75 atm
   b) Degree of dissociation of $N_2O_5 = 0.25$
   c) The density of equilibrium mixture = 16.83 g/L
   d) K_p of $N_2O_4 \rightleftharpoons 2NO_2(g)$ will be 9 atm
245. A reaction $S_8(g) \rightleftharpoons 4S_2(g)$ is carried out by taking 2 mol of $S_8(g)$ and 0.2 mol of $S_2(g)$ is a reaction vessel of 1 L. Which one is not correct if $K_c = 6.30 \times 10^{-6}$
   a) Reaction quotient is 8×10^{-4} b) Reaction proceeds in backward direction
   c) Reaction proceed is forward direction d) $K_p = 2.55 \text{ atm}^3$
246. When $NaNO_3$ is heated in a closed vessel, oxygen is liberated and $NaNO_3$ is left behind. At equilibrium,
   a) Addition of $NaNO_2$ favours reverse reaction
   b) Addition of $NaNO_3$ favours forward reaction
   c) Increasing the temperature favours forward reaction
   d) Increasing the pressure favours reverse reaction
247. Hg_2CrO_4 just begins to precipitate when equal volumes of 4×10^{-4} M $Hg_2(NO_3)_2$ and 2×10^{-5} M K_2CrO_4 are combined. What is the approximate K_{sp} value of Hg_2CrO_4?
   a) $1 \times 10^{-18} \text{ mol L}^{-1}$ b) $8 \times 10^{-9} \text{ mol L}^{-1}$ c) $2 \times 10^{-9} \text{ mol L}^{-1}$ d) $4 \times 10^{-9} \text{ mol L}^{-1}$
248. The degree of hydrolysis for a salt of strong acid and weak base
   a) Is independent of dilution
   b) Increases with dilution
   c) Increases with decreases in K_b of the bases
   d) Decreases with decrease in temperature
249. The pH of solution(s) is/are defined as the:
   a) Negative logarithm of the magnitude of hydrogen ion concentration
   b) Logarithm of reciprocal of magnitude of hydrogen ion concentration
   c) Negative power raison 10 in order to express $[H^+]$ ion concentration
   d) None of these
250. For which of the following is K_p less than K_c?
   a) $N_2O_4 \rightleftharpoons 2NO_2$
   b) $N_2 + 3H_2 \rightleftharpoons 2NH_3$
   c) $2SO_2 + O_2 \rightleftharpoons 2SO_3$

d) $CO + H_2O \rightleftharpoons CO_2 + H_2$

251. Which of the following statements(s) is (are) correct?
a) The pH of 1.0×10^{-8} M solution of HCl is 8
b) The conjugate base of $H_2PO_4^{\ominus}$ is HPO_4^{2-}
c) Autoprotolysis constant of water increases with temperature
d) When a solution of weak monoprotic acid is titrated against a strong base, at half-neutralisation, point $pH = (1/2)pK_a$

252. The pH of a buffer solution containing equimolar concentrations of sodium acetate and acetic acid is equal to:
a) K_a of CH_3COOH
b) pK_a of CH_3COOH
c) 14
d) $\log K_a$ of CH_3COOH

253. The dissociation reaction, $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ is endothermic. Which of the following changes will shift the equilibrium to the right?
a) Increasing the temperature
b) Compressing the gaseous mixture
c) Increasing the volume of the gaseous mixture
d) Adding $Cl_2(g)$ to the equilibrium mixture at a constant volume

254. An acid-base indicator has $K_a = 10^{-5}$. The acid form of the indicator is red and basic form is blue. Which of the following is/are correct?
a) At $pH = 4.52$, solution is red
b) At $pH = 5.47$, solution is blue
c) At $pH = 6$, solution is 75% red
d) At $pH = 8$, solution is 75% blue

255. The degree of dissociation of an electrolyte:
a) Depends on the nature of solute and solvent
b) Increase with increase in dilution
c) Increase with increase in temperature
d) None of the above

256. Which of the following statements is/are true about reaction quotient Q?
a) $Q \gtreqless K_c$
b) Q always increases, if reaction proceeds in forward direction
c) $Q = K_c = 1$, at equilibrium
d) $Q = K_c$, at equilibrium

257. Which of the following statements is/are correct?
a) A buffer solution contains a weak acid and its conjugate base
b) A buffer solution shows little change in pH on the addition of a small amount of acid or base
c) A buffer solution can be prepared by mixing a solution of ammonium acetate and acetic acid
d) The addition of solid potassium cyanide to water increases the pH of water

258. Which of the following statements is/are correct?
a) Arrhenius acids are also Bronsted acids but all Arrhenius bases are not Bronsted bases
b) All Bronsted bases are also Lewis bases
c) All Bronsted acids are also Lewis acids
d) A strong acid has a weak conjugate base but a strong base has a strong conjugate acid

259. The reaction which proceeds in the backward direction is
a) $Fe_3O_4 + 6HCl = 2FeCl_3 + 3H_2O$
b) $NH_3 + H_2O + NaCl = NH_4Cl + NaOH$
c) $SnCl_4 + Hg_2Cl_2 = SnCl_2 + 2HgCl_2$
d) $2CuI + I_2 + 4K^{\oplus} = 2Cu^{2+} + 4KI$

260. When two reactants A and B are mixed to give products C and D, the reaction quotient Q, at the initial stages of the reaction
a) Is zero
b) Decreases with time
c) Is independent of time
d) Increases with time

261. Which of the following is/are correct?
a) $H_2S + H_2O \rightleftharpoons H_3O^+ + HS^-$; K_c is acidity constant of H_2S
b) $AgCl + 2NH_3 \rightleftharpoons Ag(NH_3)_2Cl$; K_c is Stability constant for $Ag(NH_3)_2Cl$

c) $H_2O \rightleftharpoons H^+ + OH^-$; K_c is equilibrium constant for dissociation of water

d) $RNH_2 + H_2O \rightleftharpoons RNH_3^+ + OH^-$; K_c is basicity constant for RNH_2

262. For which of the following reactions is $K_p = K_c$?

a) $N_2 + O_2 \rightleftharpoons 2NO$ b) $C(s) + CO_2 \rightleftharpoons 2CO$ c) $CO + H_2O(v) \rightleftharpoons CO_2 + H_2$ d) $2HI \rightleftharpoons H_2 + I_2$

263. For given two equilibria attained in a container which arc correct if degree of dissociation of A and A' are α and α′

$A(s) \rightleftharpoons 2B(g) + C(g);\ K_{p_1} = 8 \times 10^{-2}$

$A'(s) \rightleftharpoons 2B(g) + D(g);\ K_{p_2} = 2 \times 10^{-2}$

a) $\frac{K_{p_1}}{K_{p_2}} = \left[\frac{(3\alpha' + 2\alpha)}{(3\alpha + 2\alpha')}\right]^3 \times \frac{\alpha}{\alpha'}$ b) $P'_C/P'_D = 4$

c) $P'_B = 2P'_C + 2P'_D$ d) $\alpha > \alpha'$

264. A buffer solution can be prepared from a mixture of:

a) CH_3COOH and CH_3COONa in water

b) CH_3COONa and HCl in water

c) NH_3 and NH_4Cl in water

d) NH_3 and NaOH in water

265. How will the lowering of temperature affect the chemical equilibrium in the system

$2NO + O_2 \rightleftharpoons 2NO_2, \Delta H < 0$

a) Relative concentration of products and reactants does not change

b) Relative concentration of products and reactants change

c) Equilibrium is shifted to the left

d) Equilibrium is shifted to the right

266. Which of the following do not change the value of K for a reaction?

a) Addition of catalyst b) Increase in temperature

c) Increase in pressure d) Removal of one of the products

267. The relationship between K_p and K_c is correctly shown as :

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

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

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

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

268. 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

a) Adding a suitable catalyst

b) Adding an inert gas

c) Decreasing the volume of the container

d) Increasing the amount of CO(g)

269. pH of following solution is not affected by dilution

a) 0.01 M CH_3COONH_4 b) 0.01 M NaH_2PO_4 c) 0.01 M NaCl d) 0.01 M $NaHCO_3$

270. When $NaNO_3$ is heated in a closed vessel oxygen is liberated and $NaNO_2$ is left behind. At equilibrium, which are correct

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

271. Which of the following is/are correct order(s) for acidic strength?

a) $HI > HBr > HCl > HF$ b) $HOF > HOCl > HOBr > HOI$ c) $BF_3 < BCl_3 < BBr_3 < BI_3$ d) $CH_4 > C_2H_6 > C_2H_2 > H_2O$

272. A solution is found to contain $[Cl^{\ominus}] = 1.5 \times 10^{-1}$ M; $[Br^{\ominus}] = 5.0 \times 10^{-4}$M; $[CrO_4^{2-}] = 1.9 \times 10^{-2}$ M
A solution of $AgNO_3$ (100% dissociated) is added to the above solution drop by drop. Which silver salt will precipitate first?
Given: $K_{sp}(AgCl) = 1.5 \times 10^{-10}, K_{sp}(AgBr) = 5.0 \times 10^{-11}, K_{sp}(Ag_2CrO_4) = 1.9 \times 10^{-12}$
a) AgCl
b) AgBr
c) Ag_2CrO_4
d) AgCl and AgBr togethers

273. 10 mL of $N/20$ NaOH solution is mixed with 20 mL of $N/20$ HCl solution. The resulting solution will:
a) Turn phenolphthalein solution pink
b) Turn blue litmus red
c) Turn methyl orange red
d) $[H^+] > [OH^-]$

274. The incorrect statement(s) is/are:
a) CH_3COOH is a weak acid
b) NH_4Cl gives an alkaline solution in water
c) CH_3COONa gives an acidic solution in water
d) NH_4OH is a strong base

275. The pressure P and volume V of an ideal gas both increase in a process :
a) Such a process is not possible
b) The work done by the system is positive
c) The temperature of the system must increase
d) Heat supplied to gas is equal to the change in internal energy

276. Which of the following statement(s) is/are correct?
a) Weak electrolytes are 100% dissociated at infinite dilution
b) $C_2H_5^-$ is conjugate base of C_2H_6
c) Boric acid although an acid but it does not donate a proton in water
d) Hydration energy is maximum for H^+ ions

277. Which of the following reactions is/are irreversible?
a) $2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$
b) $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$
c) $AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$
d) $KNO_3(aq) + NaCl(aq) \rightarrow KCl(aq) + NaNO_3(aq)$

278. Which of the following facts is/are correct?
a) $CaOCl_2$— A mixed salt
b) $NaHCO_3$—An acidic salt
c) MgOHCl— A basic salt
d) $K_2[Al_2(SO_4)_4] \cdot 24H_2O$— A complex salt

279. For the reaction, $N_2 + 3H_2 \rightleftharpoons 2NH_3 + 21.9$ Kcal, the value of the equilibrium constant will not be affected when :
a) The volume of the reaction vessel is changed
b) The total pressure of the system varies
c) The temperature of the system is changed
d) The initial concentrations of nitrogen and hydrogen are changed

280. The pH values of aqueous solutions of which of the following compounds does not change on dilution?
a) $PhCOONH_4$ b) NH_4CN c) HCOONa d) NH_4Cl

281. Which of the following statements is/are correct in the context of buffer mixtures?
a) It contains a weak acid and its conjugate base
b) It contains a weak base and its conjugate acid

c) The pH of the buffer solution does not change much on the addition of a small amount of acid or base
d) The pH of acidic buffer mixture is less than 7

282. For the reaction $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$, the equilibrium can be shifted in favour of product by
a) Increasing the $[H_2]$
b) Increasing the pressure
c) Increasing the $[I_2]$
d) By using the catalyst

283. In which of the following equilibrium reactions, would the equilibrium shift to the left on increasing the pressure?
a) $N_2 + 3H_2 \rightleftharpoons 2NH_3$
b) $H_2 + I_2 \rightleftharpoons 2HI$
c) $2O_3(g) \rightleftharpoons 3O_2$
d) $N_2O_4(g) \rightleftharpoons 2NO_2$

284. The equilibrium constant of the reactions; $SO_2 + (1/2)O_2 \rightleftharpoons SO_3$ and $2SO_2 + O_2 \rightleftharpoons 2SO_3$ are K_1 and K_2 respectively. The relationship between K_1 and K_2 is/are :
a) $K_1 = K_2$
b) $K_2 = K_1^2$
c) $K_1 = \sqrt{K_2}$
d) $K_2 = \sqrt{K_1}$

285. A solution is prepared by dissolving 1.5 g of a monoacidic base into 1.5 kg of water at 300 K, which showed a depression in freezing point by 0.165°C. When 0.496 g of the same base titrated, after dissolution, requires 40 mL of semimolar H_2SO_4 solution. If K_f of water is 1.86 K kg mol^{-1}, then select the correct statements (s) out of the following (assuming molarity = molality):
a) The pH of the solution of weak base is 12.9
b) The ionization constant of the base is 8×10^{-3}
c) The osmotic pressure of the aqueous solution of base is 21.67 atm
d) The base is 10% ionized in aqueous solution

286. Which of the following statements is/are incorrect in respect of strong acid/strong base titrations?
a) Phenolphthalein is used as an indicator
b) Methyl orange is used as an indicator
c) Methyl red has $pK_a = 6$
d) The pH range for litmus colour change is 3.0 – 4.5. Therefore, it can be used as an indicator

287. The following reaction attains equilibrium at high temperature
$N_2(g) + 2H_2O(g) + \text{heat} \rightleftharpoons 2NO(g) + 2H_2(g)$
The yield of NO is affected by
a) Compressing of reaction mixture
b) Increasing the nitrogen concentration
c) Decreasing the hydrogen concentration
d) None of the above

288. An acid-base indicator ($K_a = 3.0 \times 10^{-5}$) has acid form red and basic form blue. Which is/are correct statement(s)?
a) 75% red form will exist at pH = 4.05
b) 75% blue form will exist at pH = 5.0
c) Indicator will show a change in colour at pH = 4.53
d) Indicator will show a change in colour at pH = 5.47

289. Aqueous solution of HNO_3, KOH, CH_3COOH, and CH_3COONa of identical concentrations are provided. The pair(s) of solutions which form a buffer upon mixing is (are):
a) HNO_3 and CH_3COOH
b) KOH and CH_3COONa
c) HNO_3 and CH_3COONa
d) CH_3COOH and CH_3COONa

290. In H_3PO_4 which of the following is true?
a) $K_a = K_{a1} \times K_{a2} \times K_{a3}$
b) $K_{a1} < K_{a2} < K_{a3}$
c) $K_{a1} > K_{a2} > K_{a3}$
d) $K_{a1} = K_{a2} = K_{a3}$

291. The equilibrium constant for the reaction, $A(g) + B(g) \rightleftharpoons 2C(g)$ is 3×10^{-4} at 500K. In the presence of a catalyst the equilibrium is attained 10 times faster. The equilibrium constant in the presence of a catalyst at 500 K has the value :
a) 3×10^{-4}
b) 30×10^{-4}
c) 3×10^{-3}
d) 0.3×10^{-3}

292. Excess of $Ag_2SO_4(s)$, $BaSO_4(s)$, and $Ba_3(PO_4)_2(s)$ are simultaneously in equilibrium with distilled water. Which of the following is (are) true? Assume no hydrolysis of dissolved ions

a) $[Ag^{\oplus}] + 2[Ba^{2+}] = 2[SO_4^{2-}] + 3[PO_4^{3-}]$

b) $2[Ag^{\oplus}] + 4[Ba^{2+}] = 2[SO_4^{2-}] + 2[PO_4^{3-}]$

c) $2[Ag^{\oplus}] + 3[Ba^{2+}] = 2[SO_4^{2}] + 2[PO_4^{3-}]$

d) $[Ag^{\oplus}] + [Ba^{2+}] = [SO_4^{2-}] + [PO_4^{3-}]$

293. The pH of which solution(s) do/does not change with dilution?

a) $1M$ CH_3COONH_4

b) $CH_3COONa + CH_3COOH$ (Both 1 M each)

c) $CH_3COOH + CH_3COONH_4$ (Both 1 M each)

d) 1 M CH_3COONa

294. For which of the following reactions is $K_p = K_c$?

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

b) $2N_2O_4(g) \rightleftharpoons 2NO_2(g)$

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

d) $H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$

295. Consider the equilibrium equation; $CH_3COOH + HF \rightleftharpoons CH_3COOH_2^+ + F^-$

Which of the following statements is/are incorrect?

a) F^- is the conjugate base of HF

b) F^- is the conjugate base of CH_3COOH

c) $CH_3COOH_2^+$ is the conjugate acid of CH_3COOH

d) CH_3COOH is the conjugate acid of $CH_3COOH_2^+$

296. Which of the following statements is/are correct regarding Lewis acids?

a) Molecules having a central atom with an incomplete octer in it can act as Lewis acids

b) Molecules in which atoms of dissimilar electronegativity are joined by multiple bonds can act as Lewis acids

c) SiF_4, PF_5 and $FeCl_3$ are Lewis acids

d) Neutral species having at least one pair of electrons can act Lewis acids

297. If salt of weak acid or base is added to a solution of its acid or base respectively, the:

a) Dissociation of acid or base is diminished

b) The pH of the solution in case of acid increases and in case of base decreases

c) Mixing of two leads for common ion effect

d) None of the above

298. At constant temperature, the equilibrium constant (K_p) for the decomposition reaction

$N_2O_4 \rightleftharpoons 2NO_2$ is expressed by

$K_p = (4x^2P)/(1 - x^2)$, where P = pressure and x = extent of decomposition. Which one of the following statements is false?

a) K_p increases with increase of P

b) K_p increases with increases of x

c) K_p increases with decrease of x

d) K_p remains constant with change in P and x

299. Which of the following is (are) correct for buffer solution?

a) Acidic buffer will be effective within in the pH range ($pK_a \pm 1$)

b) Basic buffer will be effective within the pH range ($pK_w - pK_b \pm 1$)

c) $H_3PO_4 + NaH_2PO_4$ is not a buffer solution

d) Buffers behave most effectively when the [Salt]/[Acid] ratio equal to 1

300. The oxy-acid of anhydride P_2O_5:

a) H_3PO_4 b) H_3PO_3 c) HPO_3 d) None of these

301. Which is/are general property of acids?

a) They turn litmus red

b) They react with alkalies
c) They burn the skin
d) They contain H atom replaceable with metal

302. Which of the following will favour the formation of NH_3 by Haber's process?
a) Increase in temperature
b) Increase in pressure
c) Addition of catalyst
d) Addition of promoter

303. For a series of indicators, the colours and pH range over which colour change takes place are as follows

Indicator	Colour change over pH range
U	Yellow to blue pH 0.0 to 1.6
V	Red to yellow pH 2.8 to 4.1
W	Red to yellow pH 4.2 to 5.8
X	Yellow to blue pH 6.0 to 7.7
Y	Colourless to red pH 8.2 to 10.0

Which of the following statements is correct?
a) Indicator V could be used to find the equivalence point for 0.01 M acetic acid and 0.1 M ammonium hydroxide (ammonia solution) titration
b) Indicator Y colud be used to distinguish between 0.1 M HCl and 0.001 M NaOH solutions in water
c) Indicator X could be used to distinguish between solution of ammonium chloride and sodium acetate
d) Indicator W could be suitable for use in determining the concentration of acetic acid in vinegar by base titration

304. Which of the following is/are correct order(s) for acidic strength?
a) $Fe^{2+} < Fe^{3+}$
b) $K^+ < Na^+ < Li^+$
c) $Li^+ < Be^{2+} < B^{3+}$
d) $CH_3OH > C_2H_5OH > C_3H_7OH$

305. Active mass is given as :
a) $a = f.C_M$
b) $a = r.C_m$
c) Amount of a substance per unit volume
d) Number of mole per 100 litre

306. Le-Chatelier's principle is :
a) If a system in equilibrium is subjected to a change of concentration, pressure or temperature, the equilibrium shifts in the direction that tends to a null the effect of change
b) Applicable to all types of dynamic equilibrium
c) Given to study the effect of state variables on the equilibrium
d) None of the above

307. Which of the following equilibrium reactions would be affected by change in pressure?
a) $N_2 + O_2 \rightleftharpoons 2NO$
b) $2SO_2 + O_2 \rightleftharpoons 2SO_3$
c) $PCl_5 \rightleftharpoons PCl_3 + Cl_2$
d) $H_2 + Cl_2 \rightleftharpoons 2HCl$

308. Consider the following equilibrium in a closed container:
$N_2O_4(g) \rightleftharpoons 2NO_2(g)$
At a fixed temperature, the volume of the reaction container is halved. For this change, which of the following statements, holds false regarding the equilibrium constant (K_p) and degree of dissociation (α)?
a) neither K_p nor α changes
b) Both K_p and α change
c) K_p changes but α does not change
d) K_p does not change but α changes

309. A chemical reaction, $A \rightarrow B$ is said to be in equilibrium when :

a) 50% of the conversion has taken place

b) Only 10% conversion of A to B has taken place

c) The rate of transformation of A to B is just equal to the rate of transformation of B to A in the system

d) There is no change in the concentration of either A or B

310. Which of the following statements about a weak acid strong base titration is/are correct?

a) The pH after the equivalence point of the weak acid strong base titration is determined by using the K_b expression for the conjugate base

b) A buffer solution of weak acid and its conjugate base is formed before the equivalence is reached

c) The pH at the equivalence point of a weak monoprotic acid strong base titration is equal to the pH at the equivalence point of a strong acid-strong base titration

d) The increases in pH in the region near the equivalence point of a weak acid strong base titration is greater than the pH change in the same region of a strong acid strong base titration

311. In which of the following reactions would the yield of the products be increased by the application of high pressure?

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

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

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

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

312. Which is/are correct?

a) $2.303 \log K = -\Delta H^{\ominus}/RT + \Delta S^{\ominus}/R$

b) $\Delta G^{\ominus} = -2.303RT \log K$

c) $-2.303 \log K = -\Delta H^{\ominus}/RT^2 + \Delta S^{\ominus}/R$

d) $2.303 \log K = (1/RT)(\Delta H^{\ominus} + \Delta S^{\ominus})$

313. The equilibrium constant(s) K_p for the reaction, $2A(g) + B(g) \rightleftharpoons 3C + D$ is/are given as (at equilibrium) :

a) $\log_e \frac{K_{p_2}}{K_{p_1}} = \frac{\Delta H}{R} \frac{[T_2 - T_1]}{T_1 T_2}$

b) $K_p = \frac{(P_C)^3 \times (P_D)}{(P_A)^2 \times (P_B)}$

c) $K_p = \frac{(\text{mole of } C)^3 \times (\text{mole of } D)}{(\text{mole of } A)^2 \, (\text{mole of } B)} \times \left[\frac{P}{\sum \text{mole}}\right]^1$

d) $\left[\frac{d}{dT} \log_e K\right] = -\frac{\Delta H}{RT^2}$

314. Which of the following is/are correct?

a) $SiCl_4$-Lewis acid b) CN^--Lewis base c) BF_3-Lewis acid d) CH_3OH-Bronsted acid

315. Choose the correct statement:

a) pH of acidic buffer solution decreases if more salt is added

b) pH of acidic solution increases if more salt is added

c) pH of basic buffer decreases if more salt is added

d) pH of basic buffer increases if more salt is added

316. Which of the following is/are correct order(s) for basic strength?

a) $NaOH > NH_4OH > H_2O$

b) $NH_3 > N_2H_4 > NH_2OH$

c) $NH_3 > H_2O > HF$

d) $OH^- < C_2H^- < NH_2^- < C_2H_3^- < C_2H_5^-$

317. Which of the following is (are) correct when 0.1 L of 0.0015 M $MgCl_2$ and 0.1 L of 0.025 M NaF are mixed together?

(K_{sp} of $MgF_2 = 3.7 \times 10^{-8}$)

a) MgF_2 remains in solution b) MgF_2 precipitates out

c) $MgCl_2$ precipitates out d) $Cl^{\ominus}$ ions remain in solution

318. For the chemical reaction

$3X(g) + Y(g) \rightleftharpoons X_3Y(g)$

the amount of X_3Y at equilibrium is not affected by

a) Temperature and pressure
b) Temperature only
c) Pressure only
d) Temperature, pressure, and catalyst

319. For the gas phase reaction, $2SO_2 + O_2 \rightleftharpoons 2SO_3$; $\Delta H = -x$, carried out in a vessel, the equilibrium concentration of SO_2 can be increased by :

a) Increasing the temperature
b) Decreasing the pressure
c) Removing some oxygen
d) None of the above

320. 0.1 mol of CH_3NH_2 ($K_b = 5 \times 10^{-4}$) is mixed with 0.08 mol of HCl and diluted to 1 L. Which statement is correct?

a) The concentration of $H^{\oplus}$ ion is 8×10^{-11} M
b) The concentration of $H^{\oplus}$ ion is 8×10^{-5} M
c) The pH of solution is 9.8
d) The pOH of solution is 10.2

321. $CHCl_3$ does not give white ppt. with $AgNO_3$ because it:

a) Is a covalent compound
b) Does not give Cl^- ions in solution
c) Is not dissociated in water
d) None of the above

322. 2 mole each of A and B were taken in a container and the following reaction took place, $2A(g) + B(g) \rightleftharpoons 2C(g) + 2D(g)$ when the system attained equilibrium :

a) $[A] > [B]$
b) $[A] < [B]$
c) $[A] = [B]$
d) $[D] = [C]$

323. When NH_4Cl is added to a solution of NH_4OH, the:

a) Concentration of OH^- decreases
b) Dissociation of NH_4OH decreases
c) Concentration of NH_4^+ increases
d) Concentration of OH^- increases

324. Which statements is/are correct?

a) 0.1 M NH_3 solution will precipitate $Fe(OH)_2$ from a 0.1 M solution Fe^{2+}
b) 0.1 M NH_3 solution will not precipitate $Mg(OH)_2$ from a solution which is 0.2 M in $\overset{\oplus}{NH_4}$ and 0.1 M in Mg^{2+}
c) 0.1 M NH_3 solution will not precipitate AgOH from a solution which is 0.01 M in $Ag^{\oplus}$
d) Will precipitate is/are correct?

325. Which statement(s) is/are correct?

a) pH of $10^{-6}M$ NaOH is 8
b) pH of $10^{-6}M$ HCl is 6.98
c) Aqueous solution of $FeCl_3$ is acidic
d) If $[Ba^{2+}][F^-]^2 > K_{sp}$; BaF_2 will be precipitated

326. van't Hoff equation is

a) $(d/dT) \ln K = -\Delta H/RT^2$
b) $d/dT (\ln K) = +\Delta H/RT^2$
c) $(d/dT) \ln K = -\Delta H/RT$
d) $K = Ae^{-\Delta H/RT}$

327. The theory of electrolytic dissociation suggests that:

a) The electrolytes on dissolution in water split up in two types of charged particles, *i.e.*, cation and anions
b) The dissociation being a reversible process in nature
c) The properties of electrolytes in solutions are the properties of ions furnished by them
d) None of the above

328. In a reaction, $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g) + x$ kJ

The ideal conditions for the dissociation of PCl_5 is

a) More $[PCl_5]$, low pressure
b) More $[PCl_5]$, low temperature
c) More $[PCl_5]$, high pressure
d) More $[PCl_5]$, high temperature

329. NH_3 is taken in a container at a certain temperature. If its dissociation constant (K_p) has an appreciable

value, at equilibrium :

a) The concentration of ammonia changes with pressure

b) The concentration of N_2 is less than that of H_2

c) α does not change with pressure

d) K_p does not change with pressure

330. What is general criteria of choosing a suitable indicator for a given titration?

a) The indicator should have a broad pH range

b) pH at the end point of titration should be close to neutral point of indicator

c) The indicator should have neutral point at pH = 7

d) The indicator must show a sharp colour change near the equivalence point of titration point

331. Which of the following solution will have pH = 13?

a) 2 g NaOH in 500 mL solution
b) 100 mL solution of 0.05 M $Ca(OH)_2$
c) 100 mL solution of 0.1 N $Ca(OH)_2$
d) 4 g NaOH in 500 mL solution

332. A solution containing a mixture of 0.05 M NaCl and 0.05 M Nal is taken. (K_{sp} of AgCl $= 10^{-10}$ and K_{sp} of AgI $= 4 \times 10^{-16}$). When $AgNO_3$ is added to such a solution:

a) The concentration of $Ag^{\oplus}$ required to precipitate $Cl^{\ominus}$ is 2×10^{-9} mol L^{-1}

b) The concentration of $Ag^{\oplus}$ required to precipitate $I^{\ominus}$ is 8×10^{-15} mol L^{-1}

c) AgCl and AgI will be precipitate together

d) First AgI will be precipitated

333. Which of the following reactions at equilibrium in the gaseous phase would be affected by an increase in pressure?

a) $N_2O_4 \rightleftharpoons 2NO_2$
b) $CO + \frac{1}{2}O_2 \rightleftharpoons CO_2$
c) $N_2 + O_2 \rightleftharpoons 2NO$
d) $2NO_2 \rightleftharpoons 2NO + O_2$

334. The decomposition of N_2O_4 to NO_2 was carried out in choloroform at 280°C. At equilibrium, 0.2 mole of N_2O_4 and 2×10^{-3} mole of NO_2 were present in 2L of solution. The equilibrium constant(s) for the reaction $N_2O_4 \rightleftharpoons 2NO_2$ is/are :

a) 0.01×10^{-3}

b) 2.0×10^{-3}

c) 2.0×10^{-5}

d) 1.0×10^{-5}

335. Which is/are correct for a reversible reaction?

a) The reaction is never completed

b) The reactants are present in the initial stage but after that reactants and products are always present in the reaction mixture.

c) At equilibrium only products are present

d) When the gaseous phase reaction is carried out in closed space, it attains equilibrium state after suitable time

336. For the gas phase reaction

$C_2H_4 + H_2 \rightleftharpoons C_2H_6$ $(\Delta H = -32.7 \text{ kcal})$

carried out in a vessel, the equilibrium concentration of C_2H_4 can be increased by

a) Increasing the temperature
b) Decreasing the pressure
c) Removing some H_2
d) Adding some C_2H_6

337. For the equilibrium at 298 K; $N_2O_4(g) \rightleftharpoons 2NO_2(g)$;

$G^{\ominus}{}_{N_2O_4} = 100$ kJ mol^{-1} and $G^{\ominus}{}_{NO_2} = 50$ kJ mol^{-1}. If 5 mol of N_2O_4 and 2 moles of NO_2 are taken initially in one litre container than which statement are correct

a) Reaction proceeds in forward direction

b) $K_c = 1$

c) $\Delta G = -0.55$ KJ, $\Delta G^{\ominus} = 0$

d) At equilibrium $[N_2O_4] = 4.84$ M and $[NO_2] = 0.212$ M

338. H_2O acts as Bronsted acid in the following:

a) $H_2O + H_2O = H_3O^+ + OH^-$
b) $NH_3 + H_2O = NH_4^+ + OH^-$
c) $CaO + H_2O = Ca(OH)_2$
d) $Cu^{2+} + 4H_2O = Cu(H_2O)_4^{2+}$

339. A buffer solution can be prepared by mixing solutions of:
a) Sodium chloride and sodium hydroxide
b) Ammonium hydroxide and ammonium chloride
c) Formic acid and sodium formate
d) Boric acid and borax

340. Aqueous solutions of HNO_3, CH_3COOH, and CH_3COOK of identical concentrations are given. The pair(s) of the solution which may form a buffer upon mixing is(are):
a) NaOH and CH_3COOH b) HNO_3 and CH_3COOK
c) CH_3COOH and CH_3COOK d) $HNO_3 + CH_3COOH$

341. Which is/are not acidic salt(s)?
a) NaHS
b) $NaHF_2$
c) Na_2HPO_3
d) NaH_2PO_2

342. Nitrogen combines with oxygen to form nitric oxide,
$N_2(g) + O_2(g) \rightleftharpoons 2NO(g);\ \Delta H = 90\text{kJ mol}^{-1}$
The decomposition of NO is not favoured by:
a) Decrease of temperature
b) Increase of temperature
c) Increase in the concentration of nitric oxide
d) Decrease of pressure

343. Which of the following is/are correct order(s) in terms of increasing pH?
a) $\text{NaOH} > CH_3\text{COONa} > NaCl > N\text{H}_4\text{Cl}$
b) $\text{NH}_4\text{Cl} > NaCl > CH_3\text{COONa} > NaOH$
c) $\text{NaOH} > NaHCO_3 > KCl > (\text{NH}_4)_2\text{SO}_4$
d) $\text{CH}_3\text{COOH} > CH_3\text{COONa} > N\text{H}_4\text{Cl}$

344. The equilibrium constant for the reaction, $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$ is:
a) $K_c = [CO_2]$
b) $K_c = [CaO][CO_2]/[CaCO_3]$
c) $K_c = [CaCO_3]/[CaO][CO_2]$
d) $K_p = P_{CO_2}$

345. Which of the following salt solution has pH < 7?
a) NH_4F b) $Cr(NO_3)_3$ c) $[(CH_3)_3\overset{\oplus}{N}H]Cl^{\ominus}$ d) CaI_2

346. A buffer solution can be prepared from a mixture of
a) Sodium acetate and acetic acid in water
b) Sodium acetate and hydrochloric acid in water
c) Ammonia and ammonium chloride in water
d) Ammonia and sodium hydroxide in water

347. Which statement(s) about solubility product is/are correct?
a) It is the product of ionic concentrations of a soluble salt in its saturated solution at a certain temperature
b) If may be used to calculate solubility of substance
c) If the product of ionic concentration of the ions present in a solution exceeds its solubility product, the compound is precipitated out
d) None of the above

348. Which of the following represents hydrolysis?

a) $\overset{\oplus}{N}H_4 + 2H_2O \rightleftharpoons NH_4OH + H_3O^{\oplus}$ b) $\overset{\oplus}{N}H_4 + H_2O \rightleftharpoons NH_3 + H_3O^{\oplus}$

c) $HCO_3^{\ominus} + H_2O \rightleftharpoons H_2CO_3 + \overset{\ominus}{O}H$ d) $HCO_3^{\ominus} + H_2O \rightleftharpoons CO_3^{2-} + H_3O^{\oplus}$

349. Which of the following statement(s) is/are correct?
a) The pH of $1.0 \times 10^{-8} M$ 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 solution of a weak monoprotic acid is titrated against a strong base, at half-neutralization point $pH = (1/2)\, pK_a$

350. The degree of dissociation 'α' of PCl_5 is/are given by :
a) $\sqrt{\dfrac{K_p}{K_p + p}}$
b) $\sqrt{K_c . V(1-\alpha)}$
c) $\dfrac{\text{Exp. mol. wt.} - \text{Cal. mol. wt.}}{\text{Cal. mol. wt.}}$
d) None of the above

351. $H_3PO_4 \rightleftharpoons H^{\oplus} + H_2PO_4^{\oplus};\ K_{a_1}$:
$H_2PO_4^{\ominus} \rightleftharpoons H^{\oplus} + HPO_4^{2-}; K_{a_2}$:
$HPO_4^{2-} \rightleftharpoons H^{\oplus} + PO_4^{3-};\quad K_{a_3}$:
Mark out the incorrect statements:
a) $K_{a_1} > K_{a_2} > K_{a_3}$
b) $pH(H_2PO_4^{\ominus}) = \dfrac{pK_{a_1} + pK_{a_2}}{2}$
c) Both H_3PO_4 and $H_2PO_4^{\ominus}$ are more acidic than HPO_4^{2-}
d) Only HPO_4^{2-} is amphiprotic anion in the solution

352. Select the species which can act as an acid and base:
a) SO_4^{2-} b) HS^- c) HCO_3^- d) HSO_4^-

353. A base is a substance which:
a) Donates a lone pair of electron (Lewis concept)
b) Accepts a proton
c) Acts as a base only in presence of a acid
d) None of the above

354. Which of the following is/are correct order(s) for acidic strength?
a) $H_3PO_3 > H_3PO_4$
b) $HNO_2 > HNO_3$
c) $H_2SO_3 > H_2SO_4$
d) $ROH > H_2O$

355. For the reaction, $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$, which is the correct representation?
a) $K_p = (p_{CO_2})$ b) $K_p = K_c(RT)$ c) $K_p = (CO_2)/1$ d) None

356. In a reaction $A_2(g) + 4B_2(g) \rightleftharpoons 2AB_4(g), \Delta H < 0$. The formation of AB_4 is not favoured by
a) Low temperature and high pressure b) High temperature and low pressure
c) Low temperature and low pressure d) High temperature and high pressure

357. Which of the following reactions will not be affected by increasing the pressure?
a) $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ b) $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$
c) $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$ d) $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$

358. Unit of equilibrium constant is:
a) $(\text{mol L}^{-1})^{1-n}$ b) $(\text{mol L}^{-1})^{\Delta n}$ c) $(\text{atm})^{\Delta n}$ d) All

359. At the end point, there is a sharp change of colour in the indicator. This happens because the

a) pH a end point changes sharply
b) Structure of the indicator changes
c) Colour of indicator is adsorbed by water
d) Dissociation constant of acids and base differ by 10

360. Strong electrolyte(s) is/are those which:
a) Do not dissolve readily in water
b) Conduct electricity in molten state
c) Dissociate completely into ions at all concentrations
d) Dissociate into ions at high dilution

361. For which of the following reaction, $K_p \neq K_c$?
a) $2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$
b) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
c) $H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$
d) $2N_2O_4(g) \rightleftharpoons 2NO_2(g)$

362. Which of the following statements about reaction quotient, Q is/are correct?
a) At time proceeds, Q either decreases or increases
b) $Q \gtrless K_p$
c) $Q = 1$ at equilibrium
d) $Q = K_p$ at equilibrium

363. Reaction between barium chloride and sodium sulphate goes to completion because :
a) Barium sulphate is almost insoluble
b) The reaction is reversible
c) The solubility of barium chloride decreases
d) The reaction is irreversible

364. Which of the following is/are Lewis acid(s)?
a) NH_3
b) Mg^{2+}
c) $AlCl_3$
d) Ag^+

365. The contents of equilibrium mixture of each set given below are transferred to another flask having volume twice to the original flask. In which set equilibrium will be affected.
a) $N_2 + 3H_2 \rightleftharpoons 2NH_3$
b) $N_2 + O_2 \rightleftharpoons 2NO$
c) $PCl_5 \rightleftharpoons PCl_3 + Cl_2$
d) $SO_2 + \frac{1}{2}O_2 \rightleftharpoons SO_3$

366. Which are true for the reaction: $A_2 \rightleftharpoons 2C + D$?
a) If $\Delta H = 0$; K_p and increases with temperature and dissociation temperature
b) If $\Delta H = +\text{ve}$, K_p increases with temperature and dissociation of A_2 increases
c) If $\Delta H = -\text{ve}$; K_p decreases with temperature and dissociation of A_2 decreases
d) $K_p = 4\alpha^3 \left[\frac{P}{1 + 2\alpha}\right]^2$

367. A strong electrolyte in aqueous solution exhibits:
a) Almost completely dissociated
b) Hydration
c) Partial dissociation
d) None of the above

368. Which are correct for the following reaction?

$$\underset{A}{[Cu(H_2O)_3OH]^+} + \underset{B}{[Al(H_2O)_6]^{3+}} \longrightarrow \underset{C}{[Cu(H_2O)_4]^{2+}} + \underset{D}{[Al(H_2O)_5OH]^{2+}}$$

a) A is base and B is acid
b) C is conjugate acid of A
c) B is conjugate acid of D
d) B is conjugate base of D

369. Which of the following acids form more than one kind of salts?

a) H_3BO_3 b) HF c) HI d) H_3PO_2

370. Which of the following is/are acidic salt(s)?

a) $NaHSO_4$ b) NaHS c) $NaHSO_3$ d) Na_2HPO_3

371. A buffer solution can be prepared from a mixture of

a) Sodium acetate and acetic acid in water

b) Sodium acetate and HCl in water

c) Ammonia and ammonium chloride in water

d) Ammonia and sodium hydroxide in water

372. Which of the following statements is/are wrong?

a) At equilibrium concentrations of reactants and products become constant because the reaction stops

b) Addition of catalyst speeds up the forward reaction more than the backward reaction

c) Equilibrium constant of an exothermic reaction decreases with increase of temperature

d) K_p is always greater than K_c

373. When HCl is passed through a saturated solution of common salt, pure NaCl is precipitated because:

a) HCl is higly soluble in water

b) The ionic product $[Na^{\oplus}][Cl^{\ominus}]$ exceed its solubility product (K_{sp})

c) The K_{sp} of NaCl is lowered by the presence of $Cl^{\ominus}$ ions

d) HCl causes precipitation

374. Which of the following statements is/are correct?

a) NH_4OH is a weak base

b) NH_4Cl forms an acidic solution in water

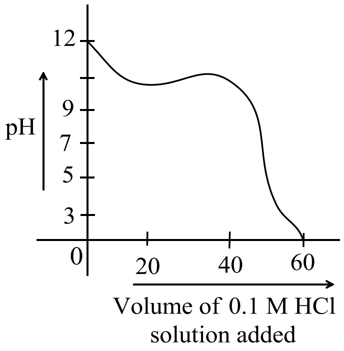
c) CH_3COOH is a weak acid

d) CH_3COONa forms an acidic solution in water

375. Which of the following is/are hard acid(s)?

a) Ag^+ b) F^- c) Zn^{2+} d) NO_3^-

376. When weak base solution (50 mL of 0.1 N NH_4OH) is titrated with strong acid (0.1 N HCl), the pH of the solution initially decreases fast and then decreases slowly till near the equivalence point (as shown in figure). Which of the following is/are correct?



a) The slow decrease of pH is due to the formation of an acidic buffer solution after the addition of some HCl

b) The slope of shown graph will be minimum when 25 mL of 0.1 N HCl is added

c) The slow decrease of pH is due to fast of basic buffer solution

d) The initial fast decrease in pH is due to fast consumption of $\overset{\ominus}{OH}$ ions by HCl

377. The equilibrium $SO_2Cl_2(g) \rightleftharpoons SO_2(g) + Cl_2(g)$ is attained at 25°C in a closed container and an inert gas, helium, is introduced. Which of the following statements is/are correct

a) The concentrations of SO_2, Cl_2, and SO_2Cl_2 change

b) More chlorine is formed

c) The concentrations of SO_2 is reduced

d) All are incorrect

378. Which of the following behave as Bronsted acids as well as Bronsted bases?
a) H_2O b) HS^- c) H_2SO_4 d) HCO_3^-

379. In the dissociation of $2HI \rightleftharpoons H_2 + I_2$, the degree of dissociation will be affected by the :
a) Addition of inert gas
b) Addition of either H_2 or I_2
c) Increase of temperature
d) Increase of pressure

380. Select the incorrect statements:
a) K_p or K_c are dimensionless if pressure or concentrations are expressed in standard state
b) The numerical value of K_p changes with experimental conditions, i.e., P, T, and C at which equilibrium is attained
c) Active mass of reactant = concentration of reactant
d) Dissolution of NH_3 in water increases with increasing pressure

381. For the reaction $N_2O_4(g) \rightleftharpoons 2NO_2(g)$, which of the following factors will have no effect on the value of equilibrium constant?
a) Temperature b) Initial concentration of N_2O_4
c) Pressure of catalyst d) Pressure

382. For the reaction, $2HCl(g) \rightleftharpoons H_2(g) + Cl_2(g)$ the equilibrium constant is 1.0×10^{-5}. What is the concentration of HCl if the equilibrium concentrations of H_2 and Cl_2 are $1.2 \times 10^{-8}\ M$ and $1.2 \times 10^{-9}\ M$ respectively?
a) $1.2 \times 10^{-3}\ M$
b) $1.2 \times 10^{-7}\ M$
c) $1.2 \times 10^{-4}\ M$
d) $1.2 \times 10^{-6}\ M$

383. Solubility of NH_3 in water is increased by :
a) Increasing pressure
b) Decreasing temperature
c) Decreasing pressure
d) Adding more water

384. For which reaction(s) given fact(s) is/are correct?
a) $H_2S + H_2O \rightleftharpoons H_3O^+ + HS^-$
K_c is ionization constant of acid
b) $H_2O + H_2O \rightleftharpoons H_3O^+ + OH^-$
K_c is ionic product of water
c) $CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$
K_c is ionization constant of base
d) $Cu^{2+} + 4NH_3 \rightleftharpoons Cu(NH_3)_4^{2+}$
K_c is stability constant of complex

385. Consider the reaction, $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g);\ \Delta H = -17.7$ kcal
The concentration of NH_3 will increase by :
a) Decreasing the temperature of the system
b) Increasing the pressure of the system
c) Decreasing the volume of the reaction vessel
d) Increasing the temperature of the system

386. A 1 L solution of pH =1, is diluted up to 10 times. What volume of a solution with pH = 2 is to be added in diluted solution so that pH does not change?
a) 10 L b) 100 L c) 1 L d) 25 L

387. To which of the solution, addition of water would not effect the pH?
a) 100 mL of 0.2 M CH_3COOH + 100 mL of 0.1 M NaOH
b) 100 mL of 0.2 M CH_3COOH + 100 mL of 0.2 M NaOH

c) 200 mL of 0.2 M $CH_3COOH + 100$ mL of 0.1 M NaOH

d) 100 mL of 0.2 M $CH_3COOH + 200$ mL of 0.2 M NaOH

388. Which of the following statements is/are correct?

a) The pH of 1.0×10^{-8} M solution of HCl is 8

b) The conjugate base of $H_2PO_4^{\ominus}$ is HPO_4^{2-}

c) The autoprotolysis constant of water increases with temperature

d) When a solution of a weak monoprotic acid is treated against a strong base, at half-neutralisation point, $pH = (1/2)pK_a$

Assertion - Reasoning Type

This section contain(s) 0 questions numbered 389 to 388. Each question contains STATEMENT 1(Assertion) and STATEMENT 2(Reason). Each question has the 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

a) Statement 1 is True, Statement 2 is True; Statement 2 **is** correct explanation for Statement 1

b) Statement 1 is True, Statement 2 is True; Statement 2 **is not** correct explanation for Statement 1

c) Statement 1 is True, Statement 2 is False

d) Statement 1 is False, Statement 2 is True

389

Statement 1: The dissociation constants of polyprotic acid are in the order $K_1 > K_2 > K_3$

Statement 2: The $[H^+]$ furnished in first step of dissociation exerts common ion effect to reduce the second dissociation so on

390

Statement 1: When a catalyst is added to a reaction mixture in equilibrium the amount of the products increases

Statement 2: The forward reaction becomes faster on adding the catalyst

391

Statement 1: When a soda water bottle is opened, the gas fizzes out.

Statement 2: Sealed soda water bottle contains CO_2 gas dissolved at high pressure. On releasing seal, the pressure decreases and CO_2 comes out.

392

Statement 1: In the titration of Na_2CO_3 with HCl using methyl orange indicator, the volume of the acid required at the equivalence point is twice that of the acid required using phenolphthalein as indicator

Statement 2: Two moles of HCl are required for the complete neutralization of one mole of Na_2CO_3

393

Statement 1: An aqueous solution of ammonium acetate acts as a buffer solution

Statement 2: A buffer solution reacts with small quantities of hydrogen or hydroxyl ions and keeps the pH almost same

394

Statement 1: The equilibrium constant may show higher or lower values with increase in temperature.

Statement 2: The change depends on the heat of reaction at equilibrium.

395

Statement 1: The equilibrium constant K_c or K_p has the unit $(\text{mol litre}^{-1})^{\Delta n}$ or $(\text{atm})^{\Delta n}$ respectively.

Statement 2: The numerical value of $K_C = K_p$ at $\Delta n = 0$.

396

Statement 1: H_3BO_3 in water behaves as monobasic acid

Statement 2: The ionisation reaction is:

$$0H_3BO_3 + H_2O \rightleftharpoons B(OH)_4^- + H^+$$

397

Statement 1: Greater the value of K, more is the fraction of initial concentration of reactants converted to products at equilibrium

Statement 2: The value of K depends on the initial concentration of reactants

398

Statement 1: In dilute benzene solutions, equimolar addition of R_3N and HCl produce a substance with a dipole moment. In the same solvent, equimolar addition of R_3N and SO_3 produce a substance having an almost identical dipole moment

Statement 2: Both HCl and SO_3 are Lewis acids and can react with the amine base to form polar substances which undergo ionic dissociation in a solvent sufficiently more polar than benzene
Moreover, (N − S) bond is a more polar

399

Statement 1: Snow does not melt easily at mountains.

Statement 2: A decrease in pressure leads to an increase in freezing point.

400

Statement 1: Due to common ion effect, the solubility of HgI_2 is expected to be less in an aqueous solution of KI than in water. But HgI_2 dissolves in an aqueous solution of KI of form a clear solution

Statement 2: $I^{\ominus}$ ion is highly polarisable

401

Statement 1: pH value of HCN solution decreases when NaCN is added to it

Statement 2: NaCN provides a common ion $CN^{\ominus}$ to HCN

402

Statement 1: The pH of NH_4OH remains unchanged on addition of NH_4Cl

Statement 2: Addition of NH_4Cl suppresses the dissociation of NH_4OH due to common ion effect

403

Statement 1: In water orthoboric acid behaves as a weak monobasic acid

Statement 2: In water orthoboric acid behaves as a proton donor

404

Statement 1: H_2SO_4 acts as a basic in the presence of $HClO_4$

Statement 2: Perchloric acid is stronger acid than H_2SO_4

405

Statement 1: HNO_3 is stronger acid than HNO_2

Statement 2: In HNO_3 there are two N to O bonds where as in HNO_2 there is only one

406

Statement 1: Ice $\rightleftharpoons$ Water, if pressure is applied water will evaporate

Statement 2: Increase of pressure pushes the equilibrium towards the side in which umber of gaseous mole decrease

407

Statement 1: On mixing equal volumes of 1 M HCl and 2 M CH_3COONa, an acidic buffer solution is formed

Statement 2: The resultant mixture contains CH_3COOH and CH_3COONa which are parts of acidic buffer

408

Statement 1: On addition of NH_4Cl to NH_4OH, pH decreases but remains greater than 7

Statement 2: Addition of $\overset{\oplus}{NH_4}$ ion decreases ionization of NH_4OH, thus $[\overset{\ominus}{OH}]$ decreases and also pH decreases

409

Statement 1: A catalyst does not influences the values of equilibrium constant

Statement 2: Catalyst influences the rate of both forward and backward reactions equally

410

Statement 1: A certain reaction is catalysed by acids and the catalytic activity of 0.1 M solutions of the acids in water decreases in the order, HCl, HCOOH, and CH_3COOH. The same reaction takes place in anhydrous NH_3, but the three acids have same catalytic effect in 0,1 M solution

Statement 2: The order of catalytic activity in water is the same as the order of acidity. In anhydrous NH_3 all the three acids are strong

411

Statement 1: Addition of $Ag^{\oplus}$ ions to a mixture of aqueous NaCl and NaBr solution will first precipitate AgBr rather than AgCl

Statement 2: K_{sp} AgCl $<$ K_{sp} of AgBr

412

Statement 1: The value of K for a reaction may increase or decrease with increase in temperature depending upon whether the reaction is exothermic or endothermic

Statement 2: With increase in temperature, the extent of reaction increases

413

Statement 1: For the reaction
$H_2 + I_2 \rightleftharpoons 2HI, K_p = K_c$

Statement 2: In this reaction, the sum of stoichiometric coefficient of reactants is equal to the sum of stoichiometrie coefficients of products

414

Statement 1: The dissociation of PCl_5 decreases on increasing pressure.

Statement 2: An increase in pressure favours the forward reaction.

415

Statement 1: A catalyst does not influence equilibrium constant of reaction but it simply helps in attaining the equilibrium earlier.

Statement 2: A catalyst increase both the rate of forward reaction and backward reaction.

416

Statement 1: Water boils at higher temperature in pressure cooker.

Statement 2: Increase in pressure leads to an increase in boiling point.

417

Statement 1: NaCl solution can be purified by passage of hydrogen chloride through brine.

Statement 2: This type of purification is based on Le- Chatelier principle .

418

Statement 1: For gaseous reaction when $\Delta n = 0, K_P = K_c$, Δn=change n the number fo gas moles.

Statement 2: For gaseous reaction $K_p=K_c (RT)\Delta n$

419

Statement 1: K_p can be equal to or less than or even greater than the value of K_c

Statement 2: $K_p = K_c (RT)^{\Delta n}$
Relation between K_p and K_c depends on the change in the number of moles of gaseous reactants and products

420

Statement 1: The pH of an aqueous solution of CH_3COOH remains unchanged on the addition of CH_3COONa

Statement 2: The ionization of CH_3COOH is suppressed by the addition of CH_3COONa

421

Statement 1: pH of a neutral solution is always 7

Statement 2: pH of a solution does not depend upon temperature

422

Statement 1: For $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, the equilibrium constant is K
The for $\frac{1}{2}$ $N_2(g) + \frac{3}{2}H_2(g) \rightleftharpoons NH_3(g)$, the equilibrium constant will be $\sqrt{K}$
Statement 2: If concentrations are changed to half, the equilibrium constants will be halved

423

Statement 1: The solubility of gases always increases with increase in pressure.

Statement 2: High pressure favours the change where volume decreases.

424

Statement 1: On opening a sealed soda bottle dissolved CO_2 escapes

Statement 2: Gas escapes to reach the new equilibrium condition of lower pressure.

425

Statement 1: The pH of pure water is less than 7 at 60°C

Statement 2: As the temperature increases, pure water becomes slightly acidic

426

Statement 1: Solution of $AlCl_3$ in water is neutral

Statement 2: $[Al(H_2O)_6]^{3+}$ is formed

427

Statement 1: Solubility of AgCl is less in 0.1 M NaCl than in water

Statement 2: In presence of NaCl, the solubility of AgCl is lowered on account of common ion effect

428

Statement 1: Adding inert gas to dissociation equilibrium of N_2O_4 at constant pressure and temperature increases the dissociation
Statement 2: Molar concentration of the reactants and products decreases

429

Statement 1: If a solution with $pH = 2$ is diluted to double the volume, the pH of the solution will fall to 1
Statement 2: pH is inversely proportional to the volume of the solution

430

Statement 1: For $PCl_3(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$, if more Cl_2 is added the equilibrium will shift in backward direction. Hence, equilibrium constant will decrease
Statement 2: Addition of inert gas to the equilibrium mixture at constant volume does not alter the equilibrium

431

Statement 1: pH of HCl solution is less than that of acetic acid of the some concentration

Statement 2: In equimolar solution, the number of titrable protons present in HCl is less than that present in acetic acid

432

Statement 1: When small amount of acid or base is added to pure water, its pH undergoes a change

Statement 2: Addition of an acid or a base increases the degree of ionization of water

433

Statement 1: Equilibrium constant of a reaction increases if temperature is increased

Statement 2: The forward reaction becomes faster with increase of temperature

434

Statement 1: When a solution of CH_3COOH in water is shaken with charcoal, pH of the solution will get decreased

Statement 2: The degree of ionization of CH_3COOH increases

435

Statement 1: All Arrhenius acids are also Bronsted acids

Statement 2: All Bronsted bases are also Lewis bases

436

Statement 1: If HCl gas is passed through saturated NaCl solution, solid NaCl starts separating out

Statement 2: HCl decreases the solubility product of NaCl

437

Statement 1: Methyl red has $K_a = 10^{-5}$ and the acid form, HIn is red and its conjugate base $\text{Ind}^{\ominus}$ is yellow

Statement 2:

pH	$= 3$	5	7
$\frac{[\text{Ind}^{\ominus}]}{[\text{HIn}]}$	$= 10^{-2}$	1	10^2
Colour	$=$ Red	Orange	Yellow

438

Statement 1: Cl^- is weak base than $C_2H_5O^-$

Statement 2: Stronger is acid, weaker is its conjugate base

439

Statement 1: A is very dilute acidic solution of Cd^{2+} and Ni^{2+} gives yellow precipitate of CdS on passing hydrogen sulphide

Statement 2: Solubility product of CdS is more than that of NiS

440

Statement 1: S reacts with SO_3^{2-} and forms $S_2O_3^{2-}$

Statement 2: S is electron deficient and acts an acid and SO_3^{2-} is a base in terms of Lewis acid theory

441

Statement 1: The equilibrium constant is fixed and characteristic for any given chemical reaction at a specified temperature

Statement 2: The composition of the final equilibrium mixture at a particular temperature depends upon the starting amount of reactants

442

Statement 1: pH of water increases with an increase in temperature

Statement 2: K_w or water increases with increase in temperature

443

Statement 1: Buffer system of carbonic acid and sodium bicarbonate is used for the precipitation of hydroxides of third group elements

Statement 2: It maintains the pH to a constant value, about 7.4

444

Statement 1: The active mass of pure solid and pure liquid is taken unity

Statement 2: The active mass of pure solids and liquids depends on the density and molecular mass. The density and molecular of a mass of pure liquids and solids are constant

445

Statement 1: Methyl orange is used as indicator in Na_2CO_3 titrating against HCl solution

Statement 2: The pH range of methyl orange is 3.1 to 4.5

446

Statement 1: pH of 10^{-8} M HCl is not equal to 8

Statement 2: HCl does not dissociate property in very dilute solution

447

Statement 1: The pH of a buffer solution containing equal moles of acetic acid and sodium acetate is 4.8 (pK_a of acetic acid is 4.8)

Statement 2: The ionic product of water at 25°C is 10^{-14} mol^2 L^{-2}. The correct answer is

448

Statement 1: Catalyst affects the final state of the equilibrium.

Statement 2: It enables the system to attain a new equilibrium state by complexing with the reagents.

449

Statement 1: $CO + NaOH \xrightarrow[\text{High } T]{\text{High } P} HCOONa$

Statement 2: CO although being neutral can acts as acid in the given reaction

450

Statement 1: $\Delta G = \Delta G^0 + 2.303RT \log Q$ where Q is reaction quotient.

Statement 2: Q may be greater or lesser than K_c or equal to K_c.

451

Statement 1: Sb^{3+} is not precipitated as sulphide when H_2S (g) is passed in alkaline solution

Statement 2: $[S^{2-}]$ ion in basic medium is inadequate for precipitation

452

Statement 1: A solution of$FeCl_3$in water produce brown precipitate on standing

Statement 2: Hydrolysis of $FeCl_3$ takes place in water

453

Statement 1: pH of a buffer changes with temperature

Statement 2: Ionic product of water (K_w) changes with temperature

454

Statement 1: pK_a of a weak acid becomes equal to the pH of the solution at the mid-point of titration

Statement 2: The molar concentration of the proton donor and proton acceptor becomes equal at the mid-point

455

Statement 1: Hydrolysis of salt is an exothermic phenomenon

Statement 2: It involves breaking up of water molecule to produce acid and base respectively

456

Statement 1: Addition of an inert gas to the equilibrium mixture has no effects on the states of equilibrium at constant volume or at constant pressure.

Statement 2: The addition of inert gas at constant volume will not alter the concentration of the reactants as well as products of a reaction mixture.

457

Statement 1: Both reactions are Lewis acid-base reactions?
i. $NH_3 + BF_3 \rightarrow H_3N{:}BF_3$
ii. $Mg + S \rightarrow Mg^{2+} + S^{2-}$

Statement 2: Lewis acid-base reaction involve the donation of lone pair electros from base to acid. This donation results in a coordinate bond

458

Statement 1: For the reaction, $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ Unit of K_c $L^2 mol^{-2}$

Statement 2: For the reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$Equilibrium constant $K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$

459

Statement 1: pH of acidic solution is always below 7 at 25°C

Statement 2: At 25°C, the pH of 10^{-8} M HCl is 8

460

Statement 1: All strong acid in water show almost same acidic nature

Statement 2: This is due to levelling effect of water on account of its high dielectric constant and strong proton accepting tendency

461

Statement 1: A change of pressure has no effect in case of the equilibrium, $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$

Statement 2: The reaction, $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ is highly exothermic reaction

462

Statement 1: The solubility of a gas in water decreases with rise in temperature.

Statement 2: Rise in temperature increases the kinetic energy of gaseous molecules dissolved in water.

463

Statement 1: Addition of an inert gas at constant pressure to dissociation equilibrium of $PCl_5 \rightleftharpoons PCl_3 + Cl_2$ favours forward reaction.

Statement 2: $K_c = \frac{\alpha^2}{V(1-\alpha)}$ for the dissociation equilibrium of PCl_5 where α is degree of dissociation of PCl_5.

464

Statement 1: 0.1 M NaCN + 0.05 M HCl solution on mixing in equal volume from a buffer solution

Statement 2: The solution after mixing contains a weak acid and its conjugate base and thus act as buffer

465

Statement 1: Dry HCl shall not act as an acid

Statement 2: For the acidic or basic properties, the presence of water is absolutely necessary

466

Statement 1: CCl_4, C_6H_6 and liquid SO_2 are aprotic solvents

Statement 2: Aprotic solvents do not influence the acidic or basic nature of solute

467

Statement 1: The aqueous solution of CH_3COONa is alkaline in nature.

Statement 2: Acetate ion undergoes anionic hydrolysis.

468

Statement 1: Solubility of $BaSO_4$ in 0.1 M Na_2SO_4 is 10^{-9} M, hence its K_{sp} is 10^{-18}

Statement 2: Because for $BaSO_4$, $K_{sp} = S^2$

469

Statement 1: Heat given out during neutralisation of NaOH and HF is −13.7 kcal/eq.

Statement 2: F^- ion is more easily hydrated and thus heat of neutralisation of HF and NaOH is more

470

Statement 1: Solubility of AgCl is more in conc. HCl than in water

Statement 2: AgCl form a complex with conc. HCl and thus solubility of AgCl increases in conc. HCl

471

Statement 1: The dissociation constant of water at 60°C is 10^{-13}

Statement 2: The pH of water is 6.5 and that it behaves as acid at 60°C

472

Statement 1: On cooling in a freezing mixture, colour of the mixture turns to pink from deep blue for a reaction

$$\underset{\text{(Pink)}}{Co(H_2O)_6{}^{2+}(aq)} + 4Cl^{\ominus}(aq) \rightleftharpoons \underset{\text{(Blue)}}{CoCl_4{}^{2-}(aq)} + 6H_2O(l)$$

Statement 2: The reaction is endothermic in forward reaction, so on cooling the reaction, deep blue colour appears

473

Statement 1: The amino acid glycine predominantly exists in the form of $^{\oplus}NH_3CH_2COOH^{\ominus}$

Statement 2: The conjugate acid of glycine is $NH_2CH_2COO^{\ominus}$

474

Statement 1: The synthesis of NH_3 in Haber's process needs 500°C and 200 atm pressure inspite of the fact that reaction is favoured at high P and low T according to Le-Chatelier's principle.

Statement 2: The high temperature is required to attain higher energy of activation for the reaction because bond energy of N_2 and H_2 are high.

475

Statement 1: A solution contains 0.1 M each of $Pb^{2+}, Zn^{2+}, Ni^{2+}$ ions. If H_2S is passed into this solution at 25°C

$Pb^{2+}, Ni^{2+}, Zn^{2+}$ will get precipitated simultaneously

Statement 2: Pb^{2+} and Zn^{2+} will get precipitated if the solution contains 0.1 M HCl

$[K_1\ H_2S = 10^{-7}, K_2\ H_2S = 10^{-14}, K_{sp}\ PbS = 3 \times 10^{-29}. K_{sp}\ NiS = 3 \times 10^{-19}. K_{sp}\ Zn\ S\backslash\ 10^{-25}]$

476

Statement 1: In the acid-base titration involving a strong base and a weak acid, methyl orange can be used as an indicator

Statement 2: Methyl orange changes its colour in pH range 3 to 5

477

Statement 1: Salting out action of sodium soap in presence of NaCl is based on common ion effect

Statement 2: Salting out action of soap is based on the fact that as the concentration of Na^+ increases, the RCOONa shows precipitation because $[RCOO^-][Na^+] > K_{sp}$

478

Statement 1: In acidic medium, Zn^{2+} is not precipitated by S^{2-} ions

Statement 2: Common ion effect reduces the concentration of S^{2-} ions to the minimum level

479

Statement 1: For every chemical reaction at equilibrium, standard Gibbs energy of reaction is zero.

Statement 2: At constant temperature and pressure, chemical reactions are spontaneous in the direction of decreasing Gibbs energy.

480

Statement 1: The acidic nature of some cations is:

$$Al^{3+} > Be^{2+} > Na^+ > K^+$$

Statement 2: More is the effective nuclear charge on cation more is its acidic nature

481

Statement 1: Addition of neon to $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ equilibrium at constant volume does not affect this equilibrium

Statement 2: Active masses of reactants and products do not change when volume remains constant

482

Statement 1: The reaction, $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$ is favoured in the forward direction with increase of pressure

Statement 2: The reaction is exothermic

483

Statement 1: Increase of temperature favour the formation of NH_3 by Haber's process

Statement 2: Increase of pressure and addition of catalyst favour the formation of NH_3

484

Statement 1: Acidic nature of boron trihalides is in the order:

$$BF_3 < BCl_3 < BBr_3 < BI_3$$

Statement 2: Basic nature of nitrogen trihalides is in the order:

$$NF_3 > NCl_3 > NBr_3 > NI_3$$

485

Statement 1: The value of K gives us a relative idea about the extent to which a reaction proceeds

Statement 2: The value of K is independent of the stochiometry of reactants and products at the point of equilibrium

486

Statement 1: Effect of temperature on K_c and K_p depends on enthalpy change.

Statement 2: Increase in temperature shifts the equilibrium in exothermic direction and decrease in temperature shifts the equilibrium position in endothermic direction.

487

Statement 1: Solubility of AgCN in acidic solutions is greater than in pure water

Statement 2: Solubility equilibrium of AgCN is shifted in forward direction due to the formation of HCN

488

Statement 1: On cooling in a freezing mixture, colour of the mixture turns to pink from deep blue for a reaction.$CO(H_2O)_6^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons COCl_4^{2-}(aq) + 6H_2O(I)$

Statement 2: Reaction is endothermic, so on cooling the reaction moves to backward direction.

489

Statement 1: The value of K increases with increase in temperature in case of endothermic reaction

Statement 2: The increase in temperature shifts the equilibrium in the backward direction in case of exothermic reaction

490

Statement 1: The pH of human blood at body temperature is found to be 6.9

Statement 2: Blood is alkaline in nature

491

Statement 1: K_p is always greater than K_c

Statement 2: The effect of pressure is greater on the rate of reaction than the effect of concentration

492

Statement 1: There is very little difference is acid strength of H_3PO_4, H_3PO_3 and H_3PO_2

Statement 2: The hydrogens in these acids are not all bonded to oxygens. The electronegativities of P and H are almost the same

493

Statement 1: $Na_2S_2O_3$ is a salt of unstable acid

Statement 2: $H_2S_2O_3$ is a polyprotic acid

494

Statement 1: The melting point of solid (except ice) increases with increase in pressure.

Statement 2: An increase in pressure favours the change where volume decreases.

Matrix-Match Type

This section contain(s) 0 question(s). Each question contains Statements given in 2 columns which have to be matched. Statements (A, B, C, D) in **columns I** have to be matched with Statements (p, q, r, s) in **columns II**.

495.

Column-I **Column- II**

(A)	0.1 M KCN	(p)	7
(B)	$0.1\ \text{M Ph}\overset{\oplus}{\text{N}}\text{H}_3\big]\ \text{Cl}^{\ominus}$	(q)	$6.5+\frac{1}{2}\text{p}K_a$
(C)	0.1 M KCl	(r)	$7.5-\frac{1}{2}\text{p}K_b$
(D)	0.1 M CH_3COONH_4 $(K_a=K_b)$	(s)	$7.5+\frac{1}{2}\text{p}K_a-\frac{1}{2}\text{p}K_b$

CODES :

	A	**B**	**C**	**D**
a)	q	r	p	p,s
b)	r	p	p,s	q
c)	p,s	q	r	p
d)	p	p,s	q	r

496.

	Column-I		**Column- II**
(A)	Solubility of AgCl in 0.1 M HCl	(p)	$\frac{K_{\text{sp}}}{(0.1)^2}$
(B)	Solubility of $Ni(OH)_2$ in 0.1 M NaOH	(q)	$\frac{K_{\text{sp}}}{0.1}$
(C)	Solubility of $Ni(OH)_2$ in $NiCl_2$	(r)	$\frac{K_{\text{sp}}}{(0.1)^3}$
(D)	Solubility of $Al(OH)_3$ in 0.1 M NaOH	(s)	$\left(\frac{K_{\text{sp}}}{4\times 0.1}\right)^{1/2}$
(E)	Solubility of AgCN in a buffer solution of pH = 3	(t)	$\left[K_{\text{sp}}\left(1+\frac{\text{H}^{\oplus}}{K_a}\right)\right]^{1/2}$

CODES :

	A	**B**	**C**	**D**	**E**
a)	p	q	r	s	t
b)	r	s	t	p	t
c)	q	p	s	r	t
d)	t	r	p	q	t
e)	s	t	q	t	t

497.

	Column-I		**Column- II**
(A)	NH_4Cl in water	(p)	Neutral solution which does not undergo hydrolysis
(B)	CH_3COONa in water	(q)	Cationic hydrolysis

(C) NH_4CN in water	(r) Anionic hydrolysis
(D) NaCl in water	(s) Both cationic and anionic hydrolysis

CODES :

	A	**B**	**C**	**D**
a)	q	r	s	p
b)	r	q	p	s
c)	s	p	r	q
d)	p	s	q	r

498.

Column-I	**Column- II**
(A) Acidic salt	(p) $\mathrm{pH} = \frac{1}{2}(\mathrm{p}K_w - \mathrm{p}K_b - \log C)$
(B) Basic salt	(q) $\mathrm{pH} = \frac{1}{2}(\mathrm{p}K_w + \mathrm{p}K_b + \log C)$
(C) Acidic buffer	(r) $\mathrm{pOH} = \mathrm{p}K_b + \log\frac{[\mathrm{Salt}]}{[\mathrm{Base}]}$
(D) Basic buffer	(s) $\mathrm{pH} = \mathrm{p}K_a + \log\frac{[\mathrm{Salt}]}{[\mathrm{Base}]}$

CODES :

	A	**B**	**C**	**D**
a)	q	r	p	s
b)	r	s	q	p
c)	s	p	r	q
d)	p	q	s	r

499.

Column-I	**Column- II**
(A) $HSO_4^{\ominus}$	(p) Lewis acid
(B) BF_3	(q) Lewis base
(C) $\ddot{N}H_3$	(r) Bronsted acid
(D) $\overset{\ominus}{O}H$	(s) Bronsted base

CODES :

	A	**B**	**C**	**D**
a)	R,s	p	q,s	q,s

b)	p	r,s	q,s	q,s
c)	q,s	q,s	p	q
d)	r	p	r,s	q,s

500.

	Column-I		**Column- II**
(A)	0.1 M CH_3COOH ($pK_a = 4.74$) + 0.1 M CH_3COONa	(p)	Acidic buffer at its maximum capacity
(B)	0.1 M CH_3COOH + 0.01 M HCl	(q)	Buffer solution
(C)	0.1 MCH_3COOH ($pK_a = 4.74$)+ 0.1 M NH_4OH($pK_b = 4.74$)	(r)	pH < 7 at 25°C
(D)	300 mL of 0.1 M CH_3COO Na + 100 mL of 0.1 M HCl	(s)	pH $= 7$ at 25°C

CODES :

	A	**B**	**C**	**D**
a)	q	s	r	p
b)	p	r	s	q
c)	r	p	q	s
d)	s	q	p	r

501.

	Column-I		**Column- II**
(A)	Reaction is reversed	(p)	$(K)^{1/2}$
(B)	Reaction is divided by 2	(q)	K^2
(C)	Reaction is multiplied by 2	(r)	$1/K$

CODES :

	A	**B**	**C**	**D**
a)	p	q	r	
b)	r	p	b	
c)	q	r	p	
d)	b	q	r	

502.

	Column-I		**Column- II**
(A)	Hydrolysis of ethyl acetate in basic solution	(p)	Second-order reaction

(B)	Hydrolysis of ethyl acetate in acidic solution	(q)	First-order reaction
(C)	The limits of pH values of a buffer solution	(r)	$pK_a \neq 1$
(D)	The buffer capacity of a solution is maximum when the concentration of salt to the acid is	(s)	Equal

CODES :

	A	**B**	**C**	**D**
a)	r	s	p	q
b)	s	p	q	r
c)	p	q	r	s
d)	q	r	s	p

503.

	Column-I		**Column- II**
(A)	$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$	(p)	$mol\ L^{-1}$
(B)	$NH_4Cl(g) \rightleftharpoons NH_3(g) + HCl(g)$	(q)	Unitless
(C)	$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$	(r)	atm
(D)	$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$	(s)	atm^{-2}

CODES :

	A	**B**	**C**	**D**
a)	P,r	q	s	p,r
b)	q,	s	p,r	p,r
c)	p,r	p,r	q	s
d)	p,r	q	s	p,r

504.

	Column-I		**Column- II**
(A)	$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$	(p)	$mol\ L^{-1}$
(B)	$NH_4Cl(g) \rightleftharpoons NH_3(g) + HCl(g)$	(q)	Unitless
(C)	$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$	(r)	atm
(D)	$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$	(s)	atm^{-2}

CODES :

	A	**B**	**C**	**D**
a)	P,r	q	s	p,r

b)	q,	s	p,r	p,r
c)	p,r	p,r	q	s
d)	p,r	q	s	p,r

505.

Column-I	**Column- II**
(A) $\ln K = 2 - \frac{1000}{T}$	(1) 8, 2
(B) $\ln K = \frac{1}{2} - \frac{500}{T}$	(2) 4, 2
(C) $\ln K = 4 - \frac{1000}{T}$	(3) 1, 1
(D) $\ln K = 3 - \frac{4000}{T}$	(4) 6, 8

CODES :

	A	**B**	**C**	**D**
a)	3	4	2	1
b)	2	3	1	4
c)	1	4	2	3
d)	4	3	1	2

506. 100 mL of 0.01 M H_2S solution is taken to which the following quantities of 1.0 M NaOH have been added. $K_1\ (H_2S) = 10^{-7}, K_2(H_2S) = 10^{-14}$. Match the following

Column-I	**Column- II**
(A) 0.5 mL	(p) 7.0
(B) 0.5 mL	(q) 4.5
(C) 1.0 mL	(r) 9.5
(D) 1.5 mL	(s) 11.7
	(t) 12.0

CODES :

	A	**B**	**C**	**D**
a)	p	r,t	s	p
b)	q	p	r,t	s
c)	p	q	s	r,t
d)	r,t	s	q	p

507.

Column-I	**Column- II**

(A)	$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$	(p)	$K_p = K_c(RT)$
(B)	$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$	(q)	$K_p = K_c(RT)^2$
(C)	$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$	(r)	$K_p = K_c(RT)^{-2}$
(D)	$NH_4Cl(g) \rightleftharpoons NH_3(g) + HCl(g)$	(s)	$K_p = K_c$

CODES :

	A	**B**	**C**	**D**
a)	S	r	p	q
b)	r	q	r	s
c)	p	r	s	q
d)	q	s	r	p

508.

	Column-I		**Column- II**
(A)	$Li_3Na_3(AlF_6)_2$	(p)	$108x^5$
(B)	Zirconium phosphate	(q)	$2916x^8$
(C)	Bismuth (III) sulphide	(r)	$27x^4$
(D)	Aluminium hydroxide	(s)	$4x^3$
(E)	Calcium fluoride	(t)	$6912x^7$

CODES :

	A	**B**	**C**	**D**	**E**
a)	q	t	p	r	s
b)	t	s	q	p	s
c)	p	q	r	s	s
d)	r	p	s	t	s
e)	s	r	t	q	s

509.

	Column-I		**Column- II**
(A)	$Q = K$	(p)	Reaction is nearer to completion
(B)	$Q < K$	(q)	Reaction is not at equilibrium
(C)	$Q < K$	(r)	Reaction is fast in forward direction
(D)	$K >>> 1$	(s)	Reaction at equilibrium

	(t) Reaction proceeds in backward direction

CODES :

	A	B	C	D
a)	s	q,r	q,t	p
b)	q,r	q,t	p	s
c)	p	q,t	s	q,r
d)	q,t	s	p	q,r

510.

Column-I	**Column- II**
(A) $Q = K$	(p) Reaction is nearer to completion
(B) $Q < K$	(q) Reaction is not at equilibrium
(C) $Q < K$	(r) Reaction is fast in forward direction
(D) $K >>> 1$	(s) Reaction at equilibrium
	(t) Reaction proceeds in backward direction

CODES :

	A	B	C	D
a)	s	q,r	q,t	p
b)	q,r	q,t	p	s
c)	p	q,t	s	q,r
d)	q,t	s	p	q,r

511.

Column-I	**Column- II**
(A) $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$	(p) Unaffected by inert gas addition
(B) $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$	(q) Forward shift by rise in pressure and backward shirt by inert gas addition
(C) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$	(r) Unaffected by increase in pressure
(D) $PCl_3(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$	(s) Backward shift by rise in pressure and forward shift by inert gas addition

CODES :

	A	B	C	D
a)	P,r	p,r	q	s
b)	p,r	q	s	p,r

c)	s	p,r	p,r	q
d)	q,	s	p,r	p,r

512.

	Column-I		Column- II
(A)	Ratio of solubility of a salt MCN in a buffer of pH $= 3$. $(K_a = 10^{-3}/3)$ and solubility in H_2O is	(p)	4
(B)	Raito of solubility of a salt MCN in a buffer of pH $= 4$, $(K_a = 10^{-4}/7)$ and solubility in H_2O is	(q)	2
(C)	Ratio of solubility of a salt MCN in a buffer of $pH = 5$ $(K_a = 10^{-5}/8)$ and solubility in H_2O is	(r)	8
(D)	Ratio of solubility of AgCl in 0.1 M HCl and 0.3 M $AgNO_3$	(s)	3
(E)	Ratio of solubility of $Al(OH)_3$ in 0.1 M HCl and 0.2 M NaOH	(t)	

CODES :

	A	B	C	D	E
a)	p	q	r	s	q
b)	r	s	q	p	q
c)	q	p	s	q	q
d)	s	r	p	q	q

513.

	Column-I		Column- II
(A)	Dissociation of $N_2O_4(g)$ $N_2O_4(g) \rightleftharpoons 2NO_2(g)$; $\Delta H = +57.0$ kJ	(p)	Increases with temperature
(B)	Oxidation of $NH_3(g)$ $4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$ $\Delta H = -900.0$ kJ	(q)	Decreases with pressure
(C)	Oxidation of nitrogen $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$; $\Delta H = +180.0$ kJ	(r)	Increases with addition of inert gas at constant pressure
(D)	Formation of $NO_2(g)$ $NO_2 + O_3\,(g) \rightleftharpoons NO_2(g) + O_2(g); \Delta H = -200$ kJ	(s)	Decreases with temperature

CODES :

	A	B	C	D
a)	P,r	q,r,s	p	s

b)	q,r,s	p	s	p,r
c)	s	p,r	p,r	q,r,s
d)	p	s	q,r,s	p,r

514.

	Column-I		Column- II
(A)	$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$	(p)	Forward shift by rise in pressure
(B)	$2SO_2\ (g) + O_2(g) \rightleftharpoons\ 2SO_3(g)$; $\Delta H = -$ ve	(q)	Unaffected by change in pressure
(C)	$N_2(g) + O_2(g)\ \ \rightleftharpoons 2NO(g)$; $\Delta H = +$ve	(r)	Forward shift by rise in temperature
(D)	$PCl_3(g) +\ Cl_2(g) \rightleftharpoons\ PCl_5(g)$; $\Delta H = +$ ve	(s)	Forward shift by lowering the temperature

CODES :

	A	**B**	**C**	**D**
a)	P,r	p,s	p,r	q,r
b)	q,r	p,r	p,s	p,s
c)	p,s	p,s	q,r	p,r
d)	p,s	q,r	p,s	p,r

515.

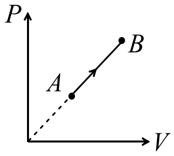
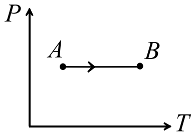
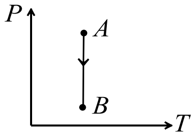
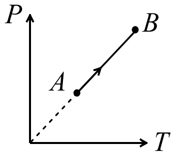
	Column-I		Column- II
(A)	10^{-2}M $(NH_4)_2\ SO_4$ solution	(p)	Cationic hydrolysis
(B)	10^{-2}M HCl solution	(q)	Anionic hydrolysis
(C)	10^{-2}M NH_3 solution	(r)	pH chages by one unit when diluted to one-tenth of its concentration
(D)	10^{-2}MCH_3COONH_4 solution	(s)	pH > 7 at 25°C

CODES :

	A	**B**	**C**	**D**
a)	S,t	r	p,q	p,t
b)	p,t	s,t	r	p,q
c)	s,t	p,q	p,t	r
d)	r	p,t	s,t	p,q

516.

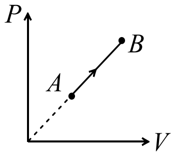
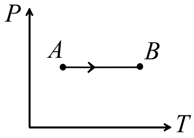
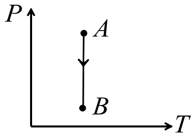
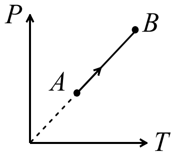
Column-I	Column- II

(A) 	(p) Temperature is increasing
(B) 	(q) Temperature is constant
(C) 	(r) Volume is constant
(D) 	(s) Pressure is increasing

CODES :

	A	**B**	**C**	**D**
a)	Q,r	p,r,s	p,s	q,r
b)	p,r,s	p,s	p ,s	q,r
c)	p,s	q,r	p,r,s	p,r,s
d)	p,s	p,r,s	q,r	p,s

517.

Column-I	**Column- II**
(A) 	(p) Temperature is increasing
(B) 	(q) Temperature is constant
(C) 	(r) Volume is constant
(D) 	(s) Pressure is increasing

CODES :

	A	**B**	**C**	**D**
a)	Q,r	p,r,s	p,s	q,r
b)	p,r,s	p,s	p ,s	q,r

c)	p,s	q,r	p,r,s	p,r,s
d)	p,s	p,r,s	q,r	p,s

518.

	Column-I		**Column- II**
(A)	$2X_{(g)} \rightleftharpoons 3Y_{(g)} + Z_{(g)}$	(1)	$\alpha = \sqrt{\frac{K_c}{V} \text{ x } 3}$
(B)	$4X_{(g)} \rightleftharpoons Y_{(g)} + Z_{(g)}$	(2)	$\alpha = [2K_cV]^{1/3}$
(C)	$2X_{(g)} \rightleftharpoons Y_{(g)} + 2Z_{(g)}$	(3)	$\alpha = \frac{4}{V}\sqrt{K_c}$
(D)	$3X_{(g)} \rightleftharpoons Y_{(g)} + Z_{(g)}$	(4)	$\alpha = \left[\frac{16V^2K_c}{27}\right]^{1/4}$

CODES :

	A	**B**	**C**	**D**
a)	4	3	2	1
b)	3	1	4	2
c)	1	2	3	4
d)	2	4	1	3

519. 50.0 mL of 0.01 M CH_2COOH solution is taken to which the following quantities of 0.01 M NaOH have been added. Match the followings

	Column-I		**Column- II**
(A)	25.0 mL	(p)	5.34
(B)	40.0 mL	(q)	11.96
(C)	50.0 mL	(r)	4.74
(D)	60.0 mL	(s)	12.22
(E)	70.0 mL	(t)	8.72

CODES :

	A	**B**	**C**	**D**	**E**
a)	r	q	t	q	s
b)	p	q	r	s	s
c)	t	s	p	q	s
d)	q	r	s	p	s
e)	s	p	q	r	s

520. 1.0 L of 0.01 M NH_3 solution is taken to which the following quantities of 1.0 M HCl is added.

($pK_b(NH_3).74$). Match the following

Column-I	Column- II
(A) 2.0 mL	(p) 11.0
(B) 5.0 mL	(q) 4.14
(C) 10.0 mL	(r) 4.74
(D) 11.0 mL	(s) 8.37

CODES :

	A	**B**	**C**	**D**
a)	p	q	r	s
b)	s	p	r	q
c)	q	r	s	p
d)	r	s	p	q

521.

Column-I	Column- II
(A) $N_2O_4(g) \rightleftharpoons 2NO_2$	(p) $K_p = K_c$
(B) $H_2 + I_2 \rightleftharpoons 2HI$	(q) K increase with increase increase temperature
(C) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$	(r) On increasing pressure reaction favour to product side
	(s) $K_c > K_p$

CODES :

	A	**B**	**C**	**D**
a)	R,s	q	p	
b)	q	p	r,s	
c)	p	r,s	q	
d)	q	p,q	r,s	

522.

Column-I	Column- II
(A) $N_2O_4(g) \rightleftharpoons 2NO_2$	(p) $K_p = K_c$
(B) $H_2 + I_2 \rightleftharpoons 2HI$	(q) K increase with increase increase temperature
(C) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$	(r) On increasing pressure reaction favour to product side
	(s) $K_c > K_p$

CODES :

	A	**B**	**C**	**D**
a)	R,s	q	p	
b)	q	p	r,s	
c)	p	r,s	q	
d)	q	p,q	r,s	

523.

	Column-I		**Column- II**
(A)	Addition of inert gas at constant pressure shifts the equilibrium in backward direction	(p)	$\Delta V \neq 0, \Delta n > 0$
(B)	Addition of inert gas at constant pressure has no effect on equilibrium	(q)	$\Delta V \neq 0, \Delta n < 0$
(C)	$K_p = K_c$	(r)	$\Delta V = 0$
(D)	Addition of inert gas shift the equilibrium in forward direction at constant p	(s)	$\Delta n = 0$

CODES :

	A	**B**	**C**	**D**
a)	r	s	q	p
b)	p	r	s	q
c)	s	q	p	r
d)	q	p	r	s

524.

	Column-I		**Column- II**
(A)	NaOH + HCl	(p)	Phenolphthalein
(B)	$H_2SO_4 + NH_4OH$	(q)	Phenol red
(C)	$CH_3COOH + NH_4OH$	(r)	Bromocresol green
(D)	$KOH + H_2SO_4$	(s)	Methyl orange

CODES :

	A	**B**	**C**	**D**
a)	r	q	p,q,s	p,s
b)	p,s	r	q	p,q,s

c)	p,q,s	p,s	r	q
d)	q	p,q,s	p,s	r

Linked Comprehension Type

This section contain(s) 57 paragraph(s) and based upon each paragraph, multiple choice questions have to be answered. Each question has atleast 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

Paragraph for Question Nos. 525 to -525

During thermal dissociation, with increase in the number of molecules, the volume increases and in consequence, the density decrease. As the temperature rises, more and more dissociation takes place, and when practically complete dissociation occurs the density reaches its lowest limit

The fraction of the total number of molecules which suffers dissociation is called the degree of dissociation. Gas density measurements can be used to determine the degree of dissociation. Let us take by general case where one molecule of a substance A splits into 'n' molecule of B on heating

$An(\mathrm{g}) \rightleftharpoons nB(\mathrm{g})$

$a \qquad 0 \quad t = 0$

$(a - x)\ nx \quad \mathrm{at} t_{\mathrm{eq}}$

Degree of dissociation $\alpha = \frac{x}{a}$ or $x = a\alpha$

Total number of moles $= a - a\alpha + na\alpha$

$= a[1 + (n - 1)\alpha]$

Observed molecular weight of the mixture

$$M = \frac{MA_n}{a[1 + (n - 1)\alpha]}$$

525. The K_p for the reaction $\mathrm{N_2O_4} \rightleftharpoons 2\mathrm{NO_2}$ is 640 mm at 775 K. The percentage dissociation of $\mathrm{N_2O_4}$ at equilibrium pressure of 160 mm is

a) 70% b) 30% c) 80% d) 60%

Paragraph for Question Nos. 526 to - 526

The rate of the reaction is directly proportional to the product of the active masses of the reactants raised to the suitable powers, at a given temperature

$aA + bB + cC \rightarrow$ Product

Rate $= k[a]^a[B]^b[C]^c$

If the reaction is written in reversed direction

$$k_b = \frac{1}{k_f}$$

For gaseous reaction, equilibrium constant, can also be expressed in terms of partial pressure

Equilibrium constant, K_c for

$aA + bB \rightleftharpoons cC + dD$ is

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

and $K_p = \frac{p_C^c p_D^d}{p_A^a p_B^b}$

K_p and K_c are related with each other as $K_p = K_c(RT)^{\Delta n\mathrm{g}}$

526. Calculate the partial pressure of carbon monoxide from the following data

$CaCO_3(s) \overset{\Delta}{\rightleftharpoons} CaO(s) + CO_2 \uparrow;\ K_p = 8 \times 10^{-2}$

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

a) 0.2 atm b) 0.6 atm c) 0.8 atm d) 0.4 atm

Paragraph for Question Nos. 527 to - 527

Radiochemical methods can be used to determine solubility product estimation. The measurement of radioactivity can be used to find the concentration in a solubility equilibrium giving a fair idea about various equilibrium concentrations. In an experiment, 50.00 mL of a 0.010 M $AgNO_3$ solution containing a silver isotope with a radioactivity of 75000 counts per min mL were mixed with 100 mL of a 0.03 M $NaIO_3$ solution. The mixed solution was diluted to 500 mL and filtered to remove all the $AgIO_3$ precipitate leaving behind a radioactive solution. Molar mass of $AgIO_3 = 285$ g/mol

527. The % of unprecipitated silver ions is

a) 0.25% b) 0.66% c) 0.43% d) 0.57%

Paragraph for Question Nos. 528 to - 528

Acidity or alkalinity of a solution depends upon the concentration of hydrogen ions relative to that of hydroxyl ions. In any aqueous solution, both hydrogen and hydroxyl ions coexist in accordance with equation $H_2O \rightleftharpoons H^+ + OH^-$. The product of hydrogen and hydroxyl ion concentrations is given by equation
$K_w = K_i[H_2O] = [H^+][OH^-]$
The value of the product depends only on the temperature and not on the individual ionic concentrations. If concentration of hydrogen ions exceeds that of the hydroxyl ions, the solution is said to be acidic and *vice versa* for basic,
For neutral solution, $[H^+] = [OH^-] = \sqrt{K_w}$
For acidic solution, $[H^+] > [OH^-]$ or $[H^+] > \sqrt{K_w}$
For basic solution, $[H^+] < [OH^-]$ or $[H^+] < \sqrt{K_w}$

528. On adding few drops of H_2SO_4 to water

a) $[OH^-]$ will increase b) $[OH^-]$ will decrease
c) Ionic product will increase d) Ionic product will decrease

Paragraph for Question Nos. 529 to - 529

Physical and chemical equilibrium can respond to a change in their pressure, temperature, and concentration of reactants and products. To describe the change in the equilibrium we have a principle named Le Chatelier's principle. According to this principle, even if we make some changes in equilibrium, then also the system even re-establishes the equilibrium by undoing the effect

529. Consider the following equilibrium:

$2NO_2 \rightleftharpoons 2; \Delta H = -$ve,
If O_2 is added and volume of the reaction vessel is reduced, the equilibrium

a) Shifts in the product side b) Shifts in the reactant side
c) Cannot be predicted d) Remains unchanged

Paragraph for Question Nos. 530 to - 530

Consider the chemical reaction:
Ni^{2+} (aq) + $6NH_3$(aq) $\rightleftharpoons$ $[Ni(NH_3)_6]^2$ (aq)
(Green solution) (Blue solution)
When $H^{\oplus}$(aq) is added, the colour green is favoured. Use one or more of the following interpretations to answer the questions:
i. Some unreacted Ni^{2+}(aq) is present in the solution at equilibrium
ii. Some unreacted NH_3(aq) is present in the solution at equilibrium
iii. The colour change indicates new equilibrium conditions with reduced $[Ni(NH_3)_6]^{2+}$(aq)
iv. The colour change indicates new equilibrium conditions with increased $[Ni(NH_3)_6]^{2+}$(aq)

530. The deepening of blue colour on dissolving more $Ni(NO_3)_2$ supports interpretation(s)
a) i only b) i and iv only c) ii and iv only d) i and ii only

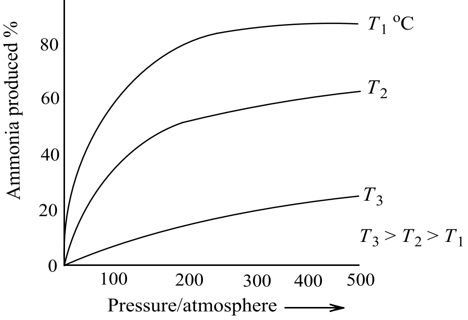
Paragraph for Question Nos. 531 to - 531

One mole of NH_4HS(s) was allowed to decompose in a 1-L container at 200°C. It decomposes reversibly to NH_3(g) and H_2S(g). NH_3(g) further undergoes decomposition to form N_2(g) and H_2(g). Finally, when equilibrium was set up, the ratio between the number of moles of NH_3(g) and H_2(g) was found to be 3
$NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g);\ K_c = 8.91 \times 10^{-2}\ M^2$
$2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g);\ K_c = 3 \times 10^{-4}\ M^2$
Answer the following:

531. What is the mole fraction of hydrogen gas in the equilibrium mixture in the gas phase?
a) 1/4 b) 3/4 c) 1/8 d) 4

Paragraph for Question Nos. 532 to - 532

The percentage of ammonia produced from nitrogen and hydrogen under certain conditions of temperature and pressure is given in the graph



Use the graph answering the following questions:

532. What happens to the percentage of ammonia produced when the temperature is increased
a) The % is decreased b) The % is increased c) No effect d) Cannot be predicted

Paragraph for Question Nos. 533 to - 533

The synthesis of ammonia is given as:
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$; $\Delta H^{\ominus} = -92.6$ kJ mol^{-1} given $K_c = 1.2$ and temperature $(T) = 375°C$
Answer the followings:

533. The expression of equilibrium constant is
    a) $K_c = \frac{[N_2][H_2]^3}{[NH_3]^2}$
    b) $K_c = \frac{[N_2][H_2]}{[NH_3]}$
    c) $K_c = \frac{[NH_3]}{[N_2][H_2]^3}$
    d) $K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$

Paragraph for Question Nos. 534 to - 534

Phosphorous pentachloride when heated in a sealed tube at 700 K it undergoes decomposition as
$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g), K_p = 38$ atm
Vapour density of the mixture is 74.25
Answer the following questions:

534. The reaction is
    a) Endothermic
    b) Exothermic
    c) May be endothermic or exothermic
    d) Unpredictable

Paragraph for Question Nos. 535 to - 535

Decomposition of ammonium chloride is an endothermic reaction. The equilibrium may be represented as:
$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$
A 6.250 g sample of NH_4Cl is placed in an evacuated 4.0 L container at 27°C. After equilibrium the total pressure inside the container is 0.820 bar and some solid remains in the container. Answer the followings

535. The value of K_p for the reaction at 300 K is
    a) 16.2
    b) 0.168
    c) 1.68
    d) 32.4

Paragraph for Question Nos. 536 to - 536

K_p and K_c are inter related as

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

Answer the following questions:

536. Which of the following have $K_p = K_c$?
    a) $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$
    b) $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$
    c) $2NO(g) + Cl_2(g) \rightleftharpoons 2NOCl(g)$
    d) $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

Paragraph for Question Nos. 537 to - 537

The relation between K_p and K_c is $K_p = K_c(RT)^{\Delta n}$ unit of K_p = $(\text{atm})^{\Delta n}$; unit of $K_c = (\text{mol L}^{-1})^{\Delta n}$
Answer the following:

537. Consider the following reactions:
   i. $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g);\ K_1$
   ii. $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g); K_2$
   iii. $CH_4(g) + 2H_2O(g) \rightleftharpoons CO_2(g) + 4H_2(g);\ K_3$
   Which of the following is correct?
   a) $K_3 = K_1/K_2$ b) $K_3 = {K_1}^2/{K_2}^3$ c) $K_3 = K_1 \times K_2$ d) $K_3 = K_1\sqrt{K_2}$

Paragraph for Question Nos. 538 to - 538

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g);\ \Delta H^{\ominus} = -22.4$ kJ
The pressure inside the chamber is 100 atm and temperature at 300 K
Answer the following questions:

538. If K_p for the given reaction is 1.44×10^{-5}, then the value of K_c will be:
   a) $\dfrac{1.44 \times 10^{-5}}{(0.082 \times 500)^{-2}}$ mol L^{-1} b) $\dfrac{1.44 \times 10^{-5}}{(8.314 \times 200)^{-2}}$ mol L^{-1}
   c) $\dfrac{1.44 \times 10^{-5}}{(0.082 \times 700)^{2}}$ mol L^{-1} d) $\dfrac{1.44 \times 10^{-5}}{(0.082 \times 300)^{-2}}$ mol L^{-1}

Paragraph for Question Nos. 539 to - 539

Mass action ratio or reaction quotient Q for a reaction can be calculated using the law of mass action
$A(g) + B(g) \rightleftharpoons C(g) + D(g)$

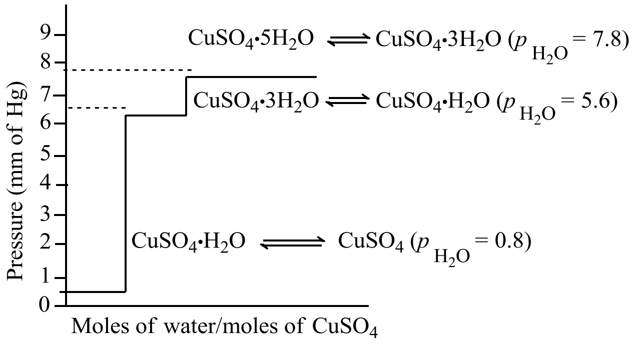
$$Q = \frac{[C][D]}{[A][B]}$$

The value of Q decides whether the reaction is at equilibrium or not
At equilibrium, $Q = K$
For an equilibrium process, $Q \neq K$
when $Q > K$, reaction will favour backward direction and when $Q < K$, it will favour forward direction
Answer the following questions:

539. The reaction quotient Q for:
   $O_2(g) + 2H_2(g) \rightleftharpoons 2H_2O(g)$
   is given by $Q = \frac{[H_2O]^2}{[O_2][H_2]^2}$. The reaction will proceed in backward direction, when
   a) $Q = K_c$ b) $Q < K_c$ c) $Q < K_c$ d) $Q = 0$

Paragraph for Question Nos. 540 to - 540

Dehydration of salts is an important class of heterogeneous reactions. The salt hydrates during dehydration often dissociate in steps to form a number of intermediate hydrates according to the prevailing pressure of moisture in contact with the solid hydrates. Thus, copper sulphate pentahydrate on dissociation yields trihydrates, monohydrates and then the anhydrous salt in the above order as follows:

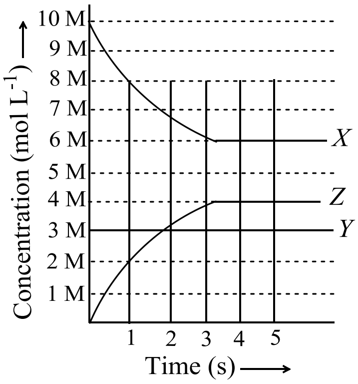


540. The equilibrium constant K_p for the equilibrium between pentahydrate and trihydrate is:

a) 7.8
b) 60.84
c) 31.36
d) 5.6

Paragraph for Question Nos. 541 to - 541

X, Y and Z react in the 1: 1: 1 stoichiometric ratio.
The concentration of X, Y and Z we are found to vary with time as shown in the figure below:



541. Which of the following equilibrium reaction represents the correct variation of concentration with time?

a) $X(g) + Y(g) \rightleftharpoons Z(g)$
b) $X(g) + Y(s) \rightleftharpoons Z(g)$
c) $Z(g) + Y(g) \rightleftharpoons X(g)$
d) $Z(g) + X(g) \rightleftharpoons Y(g)$

Paragraph for Question Nos. 542 to - 542

Two solids X and Y dissociate into gaseous products at a certain temperature as follows:
i. $X(s) \rightleftharpoons A(g) + C(g)$ and
ii. $Y(s) \rightleftharpoons B(g) + C(g)$
At a given temperature, pressure over excess solid 'X' is 40 mm of Hg and total pressure over solid '$Y(s)$' is 60 mm of Hg
Now, answer the following questions:

542. Ratio of K_p for reaction (i) to that of reaction (ii), is:

a) 4:9
b) 2:3
c) 4:9
d) 2:1

Paragraph for Question Nos. 543 to - 543

$Pb(IO_3)_2$ is a sparingly soluble salt ($K_{sp} = 2.6 \times 10^{-13}$). To 35 mL of 0.15 M $Pb(NO_3)_2$ solution, 15 mL of 0.8 M

KIO_3 solution is added, and a precipitate of $Pb(IO_3)_2$ is formed

543. Which is the limiting reactant of the reaction that takes place in the solution?
a) $Pb(IO_3)_2$
b) $Pb(NO_3)_2$
c) KIO_3
d) Both (a) and (c)

Paragraph for Question Nos. 544 to - 544

Acid-base indicator such as methyl orange, phenolphthalein, and bromothymol blue are substances which change colour according to the hydrogen ion concentration of the solution to which they are added
Most indicators are weak acids (or more rarely weak base) in which the undissociated and dissociated forms have different and distinct colours. If methyl orange is used as the example and the un-dissociated form is written as HMO, then dissociation occurs as shown below:

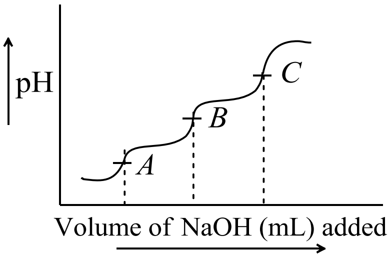
Reaction: $\underset{\text{Red}}{\text{HMO}} \rightleftharpoons \underset{\text{Colourless}}{\text{H}^{\oplus}} + \underset{\text{yellow}}{\text{MO}^{\ominus}}$

The indicator should have a sharp colour change with the equivalence point of the titration. Usually the colour change of the indicator occurs over a range of about two pH units. It should be noted that the eye cannot detect the exact end point of the titration. The pK_a of the indicator should be near the pH of the solution at the equivalence point

544. Which of the following situation exists at the equivalence point of a titration?
a) $[H^{\oplus}] = 10^{-7}$ M
b) $[H^{\oplus}] = [\overset{\ominus}{O}H]$
c) $[\overset{\ominus}{O}H] = 10^{-7}$ M
d) $\dfrac{[H^{\oplus}]}{[\overset{\ominus}{O}H]} = 10^{-14}$

Paragraph for Question Nos. 545 to - 545

Acidic solution is defined as a solution whose $[H^{\oplus}] > [\overset{\ominus}{O}H]$. Base solution has $[\overset{\ominus}{O}H] > [H^{\oplus}]$>. During acid-base titration, pH of the mixture will change depending on the amount base added. The variation is shown in the form of graph by making plot between pH vs volume of base added. These graphs are known as titration curves 100 mL of 0.1 M H_3A ($K_{a1} = 10^{-3}, K_{a2} = 10^{-5}, K_{a3} = 10^{-7}$) is titrated against 0.1 M NaOH. The titration curve is as follows



545. What is the pH at point A?
a) 3
b) 4
c) 5
d) 6

Paragraph for Question Nos. 546 to - 546

In qualitative analysis, cations of group II as well as group IV both are precipitated in the form of sulphides. Due to low value of K_{sp} of group II sulphides, group reagent is H_2S in the presence of dil. HCl, and due to high value of K_{sp} of group IV sulphides, group reagent is H_2S in the presence of NH_4OH and NH_4Cl. In a solution containing

0.1 M each of Sn^{2+}, Cd^{2+}, and Ni^{2+} ions, H_2S gas is passed
K_{sp} of SnS $= 8 \times 10^{-29}$, K_{sp} of CdS $= 1\ 5\ 10^{-28}$, K_{sp} of NiS $= 3 \times 10^{-21}$, K_1 of $H_2S = 1 \times 10^{-7}$, K_2 of $H_2S = 1 \times 10^{-14}$

546. If H_2S is passed into the above mixture in the presence of HCl, which ion will be precipitated first?
a) SnS
b) CdS
c) NiS
d) SnS and CdS (both together)

Paragraph for Question Nos. 547 to - 547

The degree of dissociation of weak electrolyte is inversely proportional to the square root of concentration. It is called Ostwald's dilution law

$\alpha = \sqrt{\frac{K_a}{c}}$ As the temperature increases, degree of dissociation will increase

$\frac{\alpha_1}{\alpha_2} = \sqrt{\frac{K_{a_1}}{K_{a_2}}}$ if concentration is same

$\frac{\alpha_1}{\alpha_2} = \sqrt{\frac{c_2}{c_1}}$ if acid is same

547. 0.01 M CH_3COOOH has 4.24% degree of dissociation, the degree of dissociation of 0.1 M CH_3COOH will be
a) 1.33%
b) 4.24%
c) 5.24%
d) 0.33%

Paragraph for Question Nos. 548 to - 548

The following solutions are mixed: 500 mL of 0.01 M $AgNO_3$ the 500 mL solution that was both 0.01 M in NaCl and 0.01 M in NaBr. Given K_{sp} AgCl $= 10^{-10}$, K_{sp}AgBr $= 5 \times 10^{-13}$

548. Calculate the $[Cl^{\ominus}]$ in the equilibrium solution
a) 5×10^{-5} M
b) 2.5×10^{-5} M
c) 5×10^{-3} M
d) 2.5×10^{-3} M

Paragraph for Question Nos. 549 to - 549

When 1.5 mol of $CuCl_2 \cdot 2H_2O$ is dissolved in enough water to make 1.0 L of solution
Given: $K_f CuCl^{\oplus} = 1.0$ (K_f is the formation constant of $CuCl^{\oplus}$)

549. $[Cu^{2+}]$ in solution is
a) 1.0 M
b) 0.5 M
c) 2.0 M
d) None

Paragraph for Question Nos. 550 to - 550

Acid rain takes place due to combination of acidic oxides with water and it is an environmental concern all over the world. Assuming rain water is uncountaminated with HNO_3 or H_2SO_4 and is in equilibrium with 1.25×10^{-4} atm CO_2. The Henry's law constant (K_H) is 1.25×10^6 torr. K_{a_1} of $H_2CO_3 = 4.3 \times 10^{-7}$
Given: $K_f CuCl^{\oplus} = 1.0$ (K_f is formation constant of $CuCl^{\oplus}$)

550. What is the pH of natural rain water?
a) 5.64 b) 7.00 c) 5.87 d) 7.40

Paragraph for Question Nos. 551 to - 551

In atmosphere, SO_2 and NO are oxidized to SO_3 and NO_2, respectively, which react with water to give H_2SO_4 and HNO_3. The resultant solution is called acid rain. SO_2 dissolves in water to form diprotic acid

$$SO_2(g) + H_2O(l) \rightleftharpoons HSO_3^{\ominus} + H^{\oplus};\ K_{a1} = 10^{-2}$$

$$HSO_3^{\ominus} \rightleftharpoons SO_3^{2-} + H^{\oplus};\ K_{a2}$$

and for equilibrium,

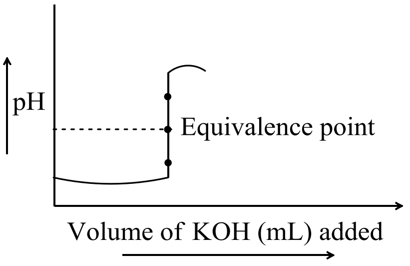
$$SO_2(aq) + H_2O(l) \rightleftharpoons SO_3^{2-}(aq) + 2H^{\oplus}(aq)$$

$$K_a = K_{a1} \times K_{a2} = 10^{-9} \text{ at } 300\text{K}$$

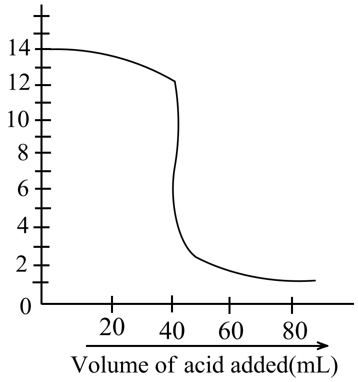
551. Which of the following reagents will give white precipitate with the aqueous solution of sulphurous acid?
a) $BaCl_2$ b) HCl c) NaCl d) KCl

Paragraph for Question Nos. 552 to - 552

In acid-base titration react rapidly to neutralize each other. Equivalence point is a point at which the acid and the base (or oxidizing agent and reducing agent) have been added in equivalent quantities. The end point is the point at which the titration stops. Since the purpose of the indicator is to stop the titration close to the point at which the acid and base were added in equivalent quantities, it is important that the equivalent point and the end point be as close as possible. The indicator must change colour at a pH close to that of a solution of the salt of the acid and base. Significantly, the pH changes most rapidly near the equivalence point. The exact shape of a titration curve depends on K_a and K_b of acid and base



552. The following curve represents titration curve of HCl against KOH. The pH at equivalent point is
Examine the titration curve below and answer the question



a) 3 b) 6 c) 7 d) 8

Paragraph for Question Nos. 553 to - 553

10 mole of NH_3 is heated at 15 atm form 27°C to 347°C assuming volume constant. The pressure at equilibrium is found to be 50 atm. The equilibrium constant for dissociation of NH_3 : $2NH_3 \rightleftharpoons N_2 + 3H_2$; $\Delta H = 91.94$ kJ

Can be written as $K_p = \frac{p_{N_2} \times (p_{H_2})^3}{(p_{NH_3})^2}$ (atm)^2

553. The degree of dissociation of NH_3 is :

a) 61.3% b) 20% c) 48% d) None of these

Paragraph for Question Nos. 554 to - 554

The dissolution of ammonia gas in water does not obey Henry's law. On dissolving, a major portion of ammonia, molecules unite with H_2O to form NH_4OH molecules. NH_4OH again dissociate into NH_4^+ and OH^- ions. In solution therefore, we have NH_3 molecules, NH_4OH molecules and NH_4^+ ions and the following equilibrium exist:

$NH_3(g)$ (pressure p and concentration C) initially $\rightleftharpoons NH_3(l) + H_2O \rightleftharpoons NH_4OH \rightleftharpoons NH_4^+ + OH^-$

Let C_1 mol/L of NH_3 pass in solution state a part of which on dissolution in water forms C_2 mol/L of NH_4OH. The solution contains C_3 mol/L of NH_4^+ ions

554. Total concentration of ammonia, which can be determined by volumetric analysis is equal to:

a) $C_1 + C_2$ b) $C_1 + C_2 + C_3$ c) $C_1 + C_3$ d) $C_2 + C_3$

Integer Answer Type

555. How many of the combinations of reactants will react until more than 98% of the limiting quantity is used up?

a. $CH_3COOH + H_2O$ b. $CH_3COO^{\ominus} + H_2O$ c. $CH_3COO^{\ominus} + H_3O^{\oplus}$

d. $CH_3COOH + KOH$ e. $CH_3COOK + HCl(aq)$ f. $HCl(g) + H_2O$

g. $Cl^{\ominus} + H_3O^{\oplus}$ h. $Cl^{\ominus} + H_2O$ i. $\overset{\oplus}{N}H_4 + KOH$

j. $\overset{\oplus}{N}H_4 + \overset{\ominus}{O}H$ k. $NH_3 + H_2O$ l. $NH_3 + H_3O^{\oplus}$

m. $NH_3 + HCl(aq)$ n. $K^{\oplus} + OH$

556. One litre of 1 M solution of an acid HA($K_a = 10^{-4}$ at 25°C) has pH $= 2$. It is diluted by water so that new pH becomes double. The solution was diluted 5×10^a mL. The value of a is…

557. How many of the following are strong electrolysis?

a. NH_3 b. NH_4Cl c. CH_3COOH d. CH_3COONa

e. HCl f. NaCl

558. For the reaction $A + B \rightleftharpoons C$, the rate constants for the forward and the reverse reactions are 4×10^2 and 2×10^2 respectively. The value of equilibrium constant K for the reaction would be

a) 1 b) 2 c) 3 d) 4

559. What is the % dissociation of H_2S, if one mole of H_2S is introduced in 1 litre vessel at 1000 K, if K_c for the reaction :

$2H_2S(g) \rightleftharpoons 2H_2(g) + S_2(g)$ is 4×10^{-6}

560. How many of the following combinations of reactants will react less than 2% of theoretically possible extent?

a. $CH_3COOH + H_2O$ b. $CH_3COO^{\ominus} + H_2O$ c. $CH_3COO^{\ominus} + H_3O^{\oplus}$

d. $CH_3COOH + KOH$ e. $CH_3COOK + HCl(aq)$ f. $HCl(g) + H_2O$
g. $Cl^{\ominus} + H_3O^{\oplus}$ h. $Cl^{\ominus} + H_2O$ i. $\overset{\oplus}{N}H_4 + KOH$
j. $\overset{\oplus}{N}H_4 + \overset{\ominus}{O}H$ k. $NH_3 + H_2O$ l. $NH_3 + H_3O^{\oplus}$
m. $NH_3 + HCl(aq)$ n. $K^{\oplus} + OH$

561. How many in a. NH_4Cl b. $NaOH$ c. $HC_2H_3O_2$ d. $NaCl$
e. $NH_3 + NH_4Cl$ f. NH_3 g. HCl h. $HClO_4$
i. $(NH_4)_2SO_4$ j. K_2SO_4
are basic?

562. 100 mL of 0.20 M weak acid HA is completely neutralised by 0.20 M NaOH. K_b for A^- is 10^{-3}, the pOH at the equivalence point is…

563. If $K_p = K_c \times [RT]^{\Delta n}$, for the reaction $2CO_2(g) + 2CaCO_3(s) \rightleftharpoons 2CaC_2(s) + 5O_2(g)$; Δn is equal to ……..

564. Calculate the pH at equilibrium point when a solution of 10^{-6} M CH_3COOH is titrated with a solution of 10^{-6} M NaOH. K_a for acid 2×10^{-5} (p$K_a = 4.7$) (Answer given in whole number)

565. An aqueous solution of 0.24 M aniline ($K_b = 4.166 \times 10^{-10}$) is mixed with NaOH solution to maintain anilinium ion concentration to $1 \times 10^{-8} M$. The pOH of NaOH solution used was …

566. How many of the following salts:
i. $NH_4C_2H_3O_2$ ii. $PhCOONH_4$ iii. $NaC_2H_3O_2$ iv. NH_4Cl
v. MgS vi. Na_2SO_4 vii. KCl
a) Hydrolyse more in water at 25°C
b) Do not hydrolyse
c) Both cation and anion hydrolyse to the same extent
d) Both cation and anion hydrolyse to different extent

567. 10 mL of 0.25 M H_2SO_4 is completely neutralised by 0.125 M solution of NH_3. The pH of the solution at the equivalence point is…, if K_b for $NH_3 = 10^{-5}$

568. Conjugate base of a weak acid has $K_b = 10^{-9}$. The equilibrium constant for the reaction of acid with strong base is…

569. The rate of disappearance of A in the reaction at equilibrium $A \rightleftharpoons B$ is given by
$-\frac{d[A]}{dt} = 2 \times 10^{-2}[A] - 4 \times 10^{-3}[B]$ at 300 K.
The equilibrium constant K_c is …….

570. For a reversible reaction $A \rightleftharpoons B$, $\log_{10} K = 1.737 - \frac{2500}{T}$ (in litre atm unit). The standard entropy, change to the colsest value in cal K^{-1} is………..

571. A certain buffer solution equals concentration of X^- and HX, K_b for X^- is 10^{-10}. The pH of buffer is…

572. K of pure water is 10^{-12} at 60°C. The pH of pure water at 60°C is…

573. Given below are two reversible reactions :
$A + B \rightleftharpoons Z$; $K_{c_1} = 24$
$2B + C \rightleftharpoons 2Y$; $K_{c_2} = 16$
The equilibrium constant K_c for the reaction,
$A + Y \rightleftharpoons Z + \frac{C}{2}$ is …………..

574. The equilibrium constant of a strong acid (HA) with weak base BOH is 10^{11}. The pH of 0.10 M solution of BA is…

575. For a reversible reaction $\frac{K_p}{K_c} = (RT)^{\Delta n}$ at 300 K. If $K_p / K_c = 14941.5$ (in litre atm unit) for a given reaction then Δn for the reaction is ….(given $\log K_p / K_c = 4.17$ and $\log 24.93 = 1.39$).

576. In a reaction at equilibrium 'x' moles of the reactant, A decompose to give 1 mole each of B and C. The experimental studies suggest that the decomposition of A at equilibrium is independent of initial concentration of A. Calculate 'x'.

577. The plot of $\ln K$ $vs. \frac{1}{T}$ shows an intercept of $\ln a = 4$. The change in standard entropy for the reaction at

equilibrium is …….cal

578. In the reaction $A + B \rightleftharpoons AB$, if the concentration of A and B is increased by a factor of 2, it will cause the equilibrium concentration of AB to change to

a) Two times to original value b) Three times to original value
c) Same d) Zero

579. How many of the following 0.1 M solutions are acidic?

a. NH_4Cl b. NaOH c. $HC_2H_3O_2$ d. NaCl
e. $NH_3 + NH_4Cl$ f. NH_3 g. HCl h. $HClO_4$
i. $(NH_4)_2SO_4$ j. K_2SO_4

580. Negative slope of the line drawn as In K_c vs. $\frac{1}{T}$ for a given reaction is -1. The heat of reaction is …….cal.

581. A reaction attains equilibrium, when the free energy change is

a) 1 b) 2 c) 3 d) 0

582. For a homogeneous chemical reaction, $K_p = K_c$ when

a) $\Delta n = 0$ b) $\Delta n = 1$ c) $\Delta n = 2$ d) $\Delta n = \infty$

583. How many in a. NH_4Cl b. NaOH c. $HC_2H_3O_2$ d. NaCl
e. $NH_3 + NH_4Cl$ f. NH_3 g. HCl h. $HClO_4$
i. $(NH_4)_2SO_4$ j. K_2SO_4
are neutral?

584. The equilibrium moles obtained during experiment for the given reaction in 1 litre vessel are shown below the reactants and products.

$2A(\mathrm{g}) + B(\mathrm{g}) \rightleftharpoons 3C(\mathrm{g}) + 3D$

Mole at equilibrium 8 16 4 4

If reaction in forward direction is to be made, the initial conc. of reactants and products should be such that reaction Quotient should be less than ……….

585. What is the sum of magic numbers of all solutions given below: (Integer value is between 50 and 60)
(Magic number of a solution = pH of solution × Weight factor)

	Solution	**Weight factor**
I	0.1 M HCN ($K_a = 10^{-10}$)	2
II	0.1M CH_3COOH + 0.1M CH_3COONa ($K_a = 10^{-5}$)	1
III	0.1 M HCl	3
IV	0.01 M NH_4OH ($K_b = 10^{-5}$)	2
V	0.01 M NaOH	0.5
VI	10 mL of 0.01 M CH_3COOH + 10 mL of 0.1 M NH_4OH	1

586. Two weak acids HA and HB have same pH when their concentration ratio is 3 : 1. The ratio of the dissociation constants of HB and HA is…

587. At equilibrium, the value of equilibrium constant K is

a) 1 b) 2 c) 3 d) 0

588. K_{sp} of $M(OH)_2$ is 5×10^{-16} at 25°C. The pH of its saturated solution at 25°C is…

589. If ΔG° for a reaction is $-$ 8290.8 cal. The K_c for the reaction 300 K is 10^n. The value of n is:

590. How many of the following cations belong to group IIA, III, IV, and V only in qualitative salt analysis?

$Sn^{2+}, Hg_2^{2+}, Pb^{2+}, Zn^{2+}, Cu^{2+}, Cr^{3+}, As^{3+}, Mg^{2+}, Sb^{3+}$

591. The equilibrium constant for the reactions
$A + B \rightleftharpoons AB$ is 0.5 at 200 K. The equilibrium constant for the reaction $AB \rightleftharpoons A + B$ would be

a) 1 b) 2 c) 3 d) 4

592. One mole of ethanol is treated with one mole of ethanoic acid at 25°C. Half of the acid changes into ester at equilibrium. The equilibrium constant for the reaction will be

a) 1	b) 2	c) 3	d) 4

593. K_{sp} of SrF_2 is 1×10^{-10}. The solubility of SrF_2 in 0.1 M NaF is $1 \times 10^{-a} M$. The value of a is…

: ANSWER KEY :

1)	c	2)	a	3)	c	4)	d	189)	b	190)	d	191)	d	192)	a
5)	a	6)	b	7)	b	8)	a	193)	d	194)	b	195)	c	196)	c
9)	c	10)	a	11)	d	12)	a	197)	a	198)	c	199)	c	200)	a
13)	b	14)	c	15)	d	16)	c	201)	a	202)	d	203)	b	204)	a
17)	a	18)	b	19)	c	20)	b	205)	c	206)	a	207)	d	208)	d
21)	c	22)	a	23)	c	24)	d	209)	c	210)	b	211)	c	212)	a
25)	c	26)	d	27)	b	28)	c	213)	a	1)	c	2)	a,b,c,d	3)	
29)	b	30)	c	31)	a	32)	a		b,d	4)	c,d,e				
33)	b	34)	a	35)	b	36)	c	5)	a,b,c	6)	a,b,c	7)	b,c,d	8)	
37)	d	38)	c	39)	c	40)	d		b,c						
41)	d	42)	a	43)	b	44)	b	9)	c,d	10)	c,d	11)	a,b,c	12)	
45)	a	46)	c	47)	b	48)	c		b,d						
49)	d	50)	a	51)	b	52)	a	13)	a,b,c	14)	a, b, c	15)	a,c	16)	
53)	c	54)	c	55)	b	56)	d		a, b, c						
57)	a	58)	d	59)	b	60)	c	17)	a,d	18)	a,b,c	19)	b,c,d	20)	
61)	c	62)	d	63)	c	64)	c		a,b,c						
65)	a	66)	b	67)	d	68)	d	21)	a,b	22)	a,b	23)	a,b	24)	
69)	b	70)	a	71)	b	72)	e		a,c,d						
73)	a	74)	b	75)	a	76)	c	25)	a,b,d	26)	a,b	27)	a,b,c	28)	
77)	b	78)	d	79)	d	80)	b		a,c						
81)	d	82)	a	83)	b	84)	b	29)	a,b,d	30)	a,c	31)	a,c,d	32)	
85)	b	86)	a	87)	a	88)	b		a,b,d						
89)	c	90)	b	91)	b	92)	d	33)	c,d	34)	b	35)	b,c,d	36)	
93)	c	94)	c	95)	d	96)	b		a,b,c						
97)	a	98)	c	99)	b	100)	a	37)	b, c	38)	b,c	39)	b,e	40)	
101)	d	102)	c	103)	c	104)	d		a, c						
105)	b	106)	c	107)	a	108)	d	41)	a,b	42)	a,b,c	43)	a, d	44)	
109)	b	110)	c	111)	d	112)	c		a,b,c,d						
113)	a	114)	b	115)	d	116)	d	45)	a,b	46)	b,c,d	47)	a	48)	
117)	b	118)	b	119)	d	120)	a		a, b, c, d						
121)	c	122)	a	123)	c	124)	c	49)	a, c, d	50)	a,b,c,d	51)	a,b,c	52)	
125)	c	126)	d	127)	a	128)	b		b,d						
129)	b	130)	b	131)	a	132)	b	53)	a,c,d	54)	c, d	55)	d	56)	
133)	d	134)	d	135)	d	136)	c		a,b,d						
137)	a	138)	b	139)	c	140)	b	57)	c,d	58)	a,b,c	59)	d	60)	
141)	a	142)	c	143)	a	144)	d		b,c,d						
145)	a	146)	a	147)	d	148)	d	61)	b,c,d	62)	b, c	63)	a,b,c,d	64)	
149)	d	150)	b	151)	c	152)	b		a, b, c						
153)	b	154)	a	155)	d	156)	d	65)	a,b,c	66)	a, b, d	67)	a,b	68)	
157)	a	158)	a	159)	b	160)	d		a,b,c						
161)	a	162)	a	163)	a	164)	b	69)	a,b	70)	c, d	71)	b, c	72)	
165)	a	166)	d	167)	c	168)	d		a,b,c,d						
169)	d	170)	a	171)	c	172)	a	73)	c,d	74)	a,b,c	75)	a,b,c	76)	
173)	c	174)	c	175)	d	176)	d		c,d						
177)	a	178)	b	179)	b	180)	a	77)	a,c	78)	a, d	79)	a	80)	
181)	a	182)	d	183)	c	184)	d		a,b,c						
185)	c	186)	b	187)	a	188)	a	81)	a, d	82)	b, c, d	83)	a,b,c	84)	

a,b,c
85) a,c,d 86) a,b,d 87) a,c 88)
a,b,d
89) b,c,d 90) c 91) a,b,c,d 92)
a, b
93) a, b, c 94) b, c 95) b,c,d 96)
c, d
97) a,b 98) a, c, d 99) a,b 100)
a, b, c, d
101) a,b,c,d 102) b,c 103) a,b,c,d 104)
b,d
105) b,c,d 106) a, b, c 107) a,c 108)
a,b,c
109) b, d 110) a,b 111) a,b,c 112)
b,c,d
113) b,d 114) a,b,c 115) a,b 116)
a, d
117) b,d 118) a,b,c 119) a,b,d 120)
a, b, d
121) a, d 122) a, b, d 123) a,b,c,d 124)
a,b,c,d
125) a,b 126) b,c,d 127) a,b,c 128)
c,d
129) a, c 130) a,c 131) a, d 132)
a,b,c
133) a,c 134) a,b,c 135) a,c 136)
b,c
137) a, b, c 138) b,d 139) b,c,d 140)
a,b,c
141) a,d 142) a,b,c 143) b,c,d 144)
b,d
145) b,c 146) a,b 147) b,c 148)
a,b,d
149) a, b, d 150) a, d 151) b,c,d 152)
a, c, d
153) a,b,c,d 154) a,b 155) a,b,c 156)
a,b
157) a,b,c 158) a,c 159) a,b,d 160)
a,b,d
161) a,b,c 162) a,c 163) b,c,d 164) d
165) a,b,d 166) b, c 167) b,c,d 168)
b,c,d
169) b, d 170) a, b, d 171) a, c, d 172)
a, b, c
173) a,b,c,d 174) a,c 175) b,c 1) c
2) c 3) c 4) b
5) b 6) c 7) d 8) c
9) c 10) a 11) c 12) b
13) d 14) b 15) a 16) a
17) a 18) d 19) a 20) c
21) a 22) a 23) c 24) b

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

: HINTS AND SOLUTIONS :

1 **(c)**
On the basis of precipitation concept an electrolyte will be precipitated firstly whose ionic product is exceeded to its solubility product. In similar ionic conc. of cations, an electrolyte is precipitated firstly for which K_{sp} is lower. In these electrolytes MnS, FeS, ZnS and HgS, HgS is precipitated firstly.

2 **(a)**
Salt of S_A/S_B do not undergo hydrolysis. So Na_2SO_4 is a salt of S_A/S_B

3 **(c)**
Precipitation starts when $Q_{sp} = K_{sp}$

$$K_{sp} = [Ca^{2+}][\overset{\ominus}{O}H]^2$$

$$\therefore [\overset{\ominus}{O}H] = \left(\frac{4 \times 10^{-6}}{0.01}\right)^{1/2} = 2 \times 10^{-2}$$

$$pOH = -\log 2 + 2$$
$$pH = 14 - \log 2 + 2 = 12 + \log 2$$

4 **(d)**
$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$
$$\Delta n_g = 2 - 4 = -2$$

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

or $1.44 \times 10^{-5} = K_c \times (0.0821 \times 773)^{-2}$

or $K_c = \frac{1.44 \times 10^{-5}}{(0.0821 \times 773)^{-2}}$

5 **(a)**
$$A(g) + 2B(g) \rightleftharpoons C(g)$$
At eq. 0.06M 0.12 M 0.216M

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

6 **(b)**
$$CH_3COOH \longrightarrow CH_3COO^{\ominus} + H^{\oplus}$$
$$CH_3COONa \longrightarrow CH_3COO^{\ominus} + Na^{\oplus}$$

Due to common ion ($CH_3COO^{\ominus}$), the suppression of ionization of CH_3COOH takes place, so the concentration of $H^{\oplus}$ decreases, so pH increases. So pH must be more than 4.3

7 **(b)**
At half neutralization,

$[B^{\oplus}] = [BOH]$; [Salt] = [base]

$$pOH = pK_b + \log \frac{[B^{\oplus}]}{[BOH]}$$

$pOH = pK_b$, (pH = 8, pOH = 6)
$\therefore pK_b = 6, K_b = 1 \times 10^{-6}$

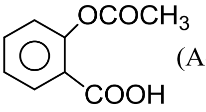
8 **(a)**
$$2NH_3 \rightleftharpoons NH_4^{\oplus} + NH_2^{\ominus}$$
$$[NH_4^{\oplus}] = [NH_2^{\ominus}] = \sqrt{K_{NH_3}} = 10^{-15}\ M$$

1 dm^3 of solution contains 10^{-15} moles $= 6.02 \times 10^{23} \times 10^{-15}$ molecules of $NH_2^{\ominus}$
1 mm^3 of solution contains $6.02 \times 10^{23} \times 10^{-15} \times 10^{-6}$
602 $NH_2^{\ominus}$ ions

9 **(c)**
$$\alpha = 50\% = \frac{50}{100} = 0.5$$
$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$
Initial 1 3 0
Final $1 - \alpha$ $3 - 3\alpha$ 2α
Total moles $= 1 - \alpha + 3 - 3\alpha + 2\alpha$
$= 4 - 2\alpha$
$= 4 - 2 \times 0.5 = 3$

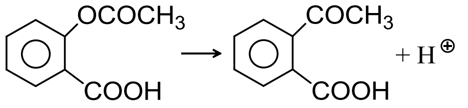
10 **(a)**
pH stands for Fench word puissance de hydrogen which means power of hydrogen ions

11 **(d)**



(Acetyl salicylic acid) (Aspirin)

Aspirin is a weak acid ad its ionization is suppressed due to common ion effect in acidic medium, i.e., in stomach. Therefore, aspirin is unionized in stomach whereas in small intestine its pH is basic. So the ionization of aspirin increases, that is why it is completely ionized in small intestine



Base in intenstine (NaOH) ⟶ $Na^{\oplus} + \overset{\ominus}{O}H$

$H^{\oplus}$ and $\overset{\ominus}{O}H$ combines and aspirin forms sodium salt
Therefore, ionization of aspirin increases

12 **(a)**

In acidic medium, H_2S is very feebly ionised giving very small concentration of sulphide ion for precipitation. Therefore, the most insoluble salts CuS and HgS are precipitated only.

13 **(b)**

$N_2 + O_2 \rightleftharpoons 2NO \; - \text{Heat}$

The above equation shows that the reaction is endothermic. Endothermic reactions are forward in forward direction at high temperature

14 **(c)**

$N_2O_4 \rightleftharpoons 2NO_2$

Initial 1 $\quad 0$

Final $1-x$ $\quad 2x$

$1 - x = 0.2$ mol $\quad 2x = 2 \times 10^{-3}$ mol

$$[N_2O_4] = \frac{0.2}{2} = 0.1\text{M} \quad [NO_2] = \frac{2 \times 10^{-3}}{2} = 10^{-3}\text{M}$$

$$K = \frac{[NO_2]^2}{[N_2O_4]} = \frac{(10^{-3})^2}{0.1} = 10^{-5}$$

15 **(d)**

$A_2B_3 \rightleftharpoons 2A^{3+} + 3B^{2-}$

$K_{\text{sp}} = (2S)^2(3S)^3 = 108S^5 = 108 \times (10^{-4})^5$

$= 108 \times 10^{-20} = 1.08 \times 10^{-20} = 1.08 \times 10^{-18}$

16 **(c)**

It is a case of simultaneous solubility of salts with a common ion. Here solubility product of CuCl is much greater than that of AgCl, it can be assumed that Cl^- in solution comes mainly from CuCl.

$$\Rightarrow \quad [Cl^-] = \sqrt{K_{\text{sp}}(\text{CuCl})} = 10^{-3}\text{ M}$$

Now for AgCl : $K_{\text{sp}} = 1.6 \times 10^{-10}$

$= [Ag^+][Cl^-]$

$= [Ag^+] \times 10^{-3}$

$$\Rightarrow \quad [Ag^+] = 1.6 \times 10^{-7}$$

18 **(b)**

i. $S^{2-} + S \rightarrow S_2^{2-} \quad \ldots k_1$

ii. $S_2^{2-} + S \rightarrow S_3^{2-} \quad \ldots k_2$

The equation constant for the reaction,

iii. $S_3^{2-} \rightarrow S^{2-} + 2S$,

Since eq. (iii) is obtained by reversing and adding equations (i) and (ii)

19 **(c)**

$NH_3 + H_2O \longrightarrow NH_4^{\oplus} + \overset{\ominus}{\text{O}}\text{H}$

$H_2O + H_2O \longrightarrow H_3O^{\oplus} + \overset{\ominus}{\text{O}}\text{H}$

Due to common ion $[OH^{\ominus}]$, the self ionization of H_2O is suppressed so the concentration of $H_3O^{\oplus}$ is decreased

20 **(b)**

Since K increases on increasing temperature, so the reaction will go forward by increasing temperature and hence is endothermic

21 **(c)**

$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$

$\Rightarrow$ At equivalence point, a salt of weak acid, strong base is formed

$$\Rightarrow \text{pH} = 7 + \frac{1}{2}(\text{p}K_a + \log C)$$

Here C = concentration of salt $= \frac{0.2 \times 500}{500+500} = 0.1$ M

[Check that 500 mL of CH_3COOH is also required]

$$\Rightarrow \text{pH} = 7 + \frac{1}{2}(4.74 + \log 0.1) = 8.87$$

22 **(a)**

$\Delta n = 2 - 1 = 1$

a. That is, with the decrease of pressure, reaction shifts towards right, i.e. proportions of NO_2 increases. Statement (a) is correct

b. Value of K increase with increase of temperature and hence reaction is endothermic i.e., $\Delta H = +\text{ve}$

Hence statement (b) is incorrect

c. $K_p = \frac{[p_{NO_2}]^2}{[p_{N_2O_4}]} = \frac{\text{atm}^2}{\text{atm}} = \text{atm}$

Hence statement (c) is incorrect

d. $N_2O_4(g) \rightleftharpoons 2NO_2(g)$

Initial 1 atm $\quad 0$

At eq. $1 - \alpha \quad 2\alpha$

$$K_p = \frac{(2\alpha)^2}{1 - \alpha} = 1.7 \times 10^3 \text{ at } 500 \text{ K}$$

$[(1 - \alpha \approx 1)$, since α is small$]$

$4\alpha^2 = 1.7 \times 10^3$

$$\alpha_1 = \sqrt{\frac{1.7 \times 10^3}{4}}$$

$\alpha = 0.206 \times 10^2$

When the pressure was 1 atm, now let it be 2 atm (100% increase)

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$

Initial 2 $\quad 0$

At eq. $2 - \alpha \quad 2\alpha$

$$K_p = \frac{(2\alpha)^2}{2 - \alpha} = 1.7 \times 10^3 \text{ at } 500 \text{ K}$$

$[(2 - \alpha \approx 2)$, since α is small$]$

$$\alpha_2 = \sqrt{\frac{1.7 \times 10^3}{2}}$$

$$\frac{\alpha_2}{\alpha_1} = \sqrt{\frac{1.7 \times 10^3 \times 4}{2 \times 1.7 \times 10^3}} = \sqrt{2} = 1.4$$

∴ When the pressure is increased 100% the decrease in α is 1.4 times which is not 50%. Hence statement is wrong

e. K_p at 600 K $= 1.78 \times 10^4$

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$

$\Delta n = 2 - 1 = 1$

Since by decrease of pressure reaction goes forward, i.e., more of N_2O_4 will dissociate. It means by decreasing pressure dissociation of N_2O_4 increases.

Hence, the statement is wrong

23 **(c)**

The dissociation constant of weak acid and its conjugate base are related by an expression

$\mathrm{p}K_a + \mathrm{p}K_a - \mathrm{p}K_w$

i.e., $\mathrm{p}K_a + 10.83 = 14$

or $\mathrm{p}K_a = 14 - 10.83 = 3.17$

or $K_a =$ antilog $(-3.17) = 6.76 \times 10^{-4}$

24 **(d)**

Salt	Solubility product	Solubility
MX	$S_1^2 = 4.0 \times 10^{-8}$	$S_1 = 2 \times 10^{-4}$
MX_2	$4S_2^3 = 3.2 \times 10^{-14}$	$S_2 = 2 \times 10^{-5}$
M_3X	$27S_3^4 = 2.7 \times 10^{-15}$	$S_3 = 1 \times 10^{-4}$

Thus, solubility order= $MX > M_3X > MX_2$

26 **(d)**

$$PCl_5 \rightleftharpoons PCl_3 + Cl_2$$

Initial 1 0 0

Final $1 - \alpha$ α α

Partial pressure $= \frac{1-\alpha}{1+\alpha}P$ $\frac{\alpha}{1+\alpha} \cdot P$ $\frac{\alpha}{1+\alpha} \cdot P$

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

$$K_p = \frac{\frac{\alpha}{1+\alpha}P \cdot \frac{\alpha}{1+\alpha} \cdot P}{\frac{1-\alpha}{1+\alpha}P} = \frac{\alpha^2 P}{1 - \alpha^2}$$

27 **(b)**

CH_3NH_2 (base) on reaction with HCl (acid) to give a salt of weak base and strong acid as $CH_3NH_3^+Cl^-$

$$CH_3NH_2 + HCl \rightarrow CH_3NH_3^+Cl^-$$

At=0 0.1 mol 0.8 mol 0.08 mol

After reaction (0.1-0.08)

=0.02 mol

So, it acts as basic buffer solution due to presence of base and salt in solution of 1 L.

$$\mathrm{pOH} = -\log_{10} K_b + \log_{10} \frac{[\mathrm{salt}]}{[\mathrm{base}]}$$

$$\mathrm{pOH} = -\log_{10} K_b + \log_{10} \frac{[CH_3NH_3^+Cl^-]}{[CH_3NH_2]}$$

$$= -\log_{10} 5 \times 10^{-4} + \log_{10} \frac{[0.08]}{[0.02]}$$

$$= -\log_{10} 5 + 4\log_{10} 10 + \log_{10} \frac{[0.08]}{[0.02]}$$

$$= -0.699 + 4 + 0.602 = 3.903$$

$$\mathrm{pH} = 14 - \mathrm{pOH}$$

$$= 14 - 3.903$$

$$= 10.097 = -\log_{10}[H^+]$$

∴ $[H^+] = 8.0 \times 10^{-11}$

28 **(c)**

$H_2S \rightleftharpoons 2H^{\oplus} + S^{2-}$

$$\therefore K_a = \frac{[H^{\oplus}]^2 [S^{2-}]}{[H_2S]}$$

$$10^{-21} = \frac{0.1 \times 0.1 \times [S^{2-}]}{0.1}$$

∴ $[S^{2-}] = 10^{-20}\ M = 10^{-20} \times 6.023 \times 10^{23}$

$= 6.023 \times 10^3$ ions

29 **(b)**

$$CH_3COOH + H_2O \rightleftharpoons CH_3COO^{\ominus} + H_3O^{\oplus}$$

Initial 1 0 0

Final $C(1 - \alpha)$ $C\alpha$ $C\alpha$

$C =$ Decinormal $= 0.1$ N

$\alpha = 1.3\% = \frac{1.3}{100} = 1.3 \times 10^{-2}$

$[H_3O^{\oplus}] = C\alpha = 0.1 \times 1.3 \times 10^{-2} = 1.3 \times 10^{-3}$

$\mathrm{pH} = -\log(1.3 \times 10^{-3}) = -\log 1.3 - \log 10^{-3}$

$= -0.11 + 3 = 2.89$

30 **(c)**

$[H_3O^{\oplus}] = 0.01 = 10^{-2}$ M

$\mathrm{pH} = -\log(10^{-2}) = 2$

31 **(a)**

$aX + H_2O \rightleftharpoons NaOH + HX$

In it HX is weak acid, so NaX is a salt of weak acid and strong base.

∴ Hydrolysis constant of NaX

$$K_h = \frac{K_W}{K_a} = \frac{1 \times 10^{-14}}{10^{-5}} = 1 \times 10^{-9}$$

For this type of salt

$$K_h = \frac{h^2}{V} = Ch^2$$

$h =$ degree of hydrolysis

$\therefore \quad 1 \times 10^{-9} = 0.1 \times h^2$

or $\quad h^2 = \frac{1\times10^{-9}}{0.1} = 1 \times 10^{-8}$

$h = 1 \times 10^{-4}$

$\therefore$ % of degree of hydrolysis on NaX salt

$= 1 \times 10^{-4} \times 100 = 1 \times 10^{-2} = 0.01\%$

32 **(a)**

With weak base and strong acid, phenolphthalein does not act an indicator

33 **(b)**

a. HOCl, it is S_A. So it is acidic

b. NaOCl, it is salt of NaOH + HOCl (Salt of S_B/W_A)

$\therefore$ It is basic

c. $NaHSO_4$ (Salt of S_A/S_B NaOH + H_2SO_4), it is neutral

d. NH_4NO_3 (Salt of W_B/S_A NH_3 + HNO_3), it is acidic

34 **(a)**

(Assume $[Al^{3+}] = [Zn^{2+}]$)

The compound which have less K_{sp} value will be precipitated first. Since the K_{sp} of $Al(OH)_3$ is less than K_{sp} of $Zn(OH)_2$, So former is precipitated

Note: *In such questions no need to calculating the exact value only approximation is required*

$$[\overset{\ominus}{O}H]_{min} \text{ for } Al^{3+} = \left(\frac{K_{sp} \text{ of } Al(OH)_3}{[Al^{3+}]}\right)^{1/3}$$

$$[\overset{\ominus}{O}H]_{min} \text{ for } Zn^{2+} = \left(\frac{K_{sp} \text{ of } Zn(OH)_2}{[Zn^{2+}]}\right)^{1/2}$$

35 **(b)**

Higher the K_{sp}, more soluble is that compound in H_2O

$\therefore K_{sp}$ of FeS (11×10^{-20}) is highest

So it is more soluble and has maximum solubility in H_2O

36 **(c)**

$$K = \frac{R_f}{R_b} = \frac{0.25}{5000} = 5.0 \times 10^{-5}$$

37 **(d)**

a. $HgCl^{\oplus} + Cl^{\ominus} \rightarrow HgCl_2 \quad \ldots K_1$

b. $HgCl_2 + Cl^{\ominus} \rightarrow HgCl_3^{\ominus} \quad \ldots K_2$

The eq. constant (k) for the reaction,

$2HgCl_2 \rightarrow HgCl^{\oplus} + HgCl_3^{\ominus}$

Can be obtained by reversing equation (a) and adding to equation (b)

$$K = \frac{1}{K_1} \times K_2 = \frac{K_2}{K_1} = \frac{8.9}{3 \times 10^6} \approx 3 \times 10^{-6}$$

38 **(c)**

$$BOH \rightleftharpoons B^{\oplus} + \cancel{\overset{\ominus}{O}}H \quad (K_b = 2.5\times10^{-6})$$

$$H^{\oplus} + \cancel{\overset{\ominus}{O}}H \rightleftharpoons H_2O \quad \left(K = \frac{1}{K_w}\right)$$

$$\overline{BOH + H^{\oplus} \rightleftharpoons B^{\oplus} + H_2O \quad K' = ?}$$

$$\therefore K' = K_b \times \frac{1}{K_w} = \frac{2.5 \times 10^{-6}}{10^{-14}} = 2.5 \times 10^8$$

39 **(c)**

When equal volumes of $BaCl_2$ and NaF solutions are mixed. (volume becomes double and concentration is halved)

$$[Ba^{2+}] = \frac{10^{-3}}{2}, [F^{\ominus}] = \frac{2\times10^{-2}}{2} = 10^{-2}$$

a. Q_{sp} of $BaF_2 = [Ba^{2+}][F^{\ominus}]^2$

$= (0.5 \times 10^{-3})(10^{-2})^2 = 5 \times 10^{-6}$

$Q_{sp} > K_{sp}$ $(6 \times 10^{-6} > 1.710^{-7})$ will be precipitated.

$$[Ba^{2+}] = \frac{10^{-3}}{2}, [F^{\ominus}] = \frac{1.5\times10^{-2}}{2}$$

b. Q_{sp} of $BaF_2 = [Ba^{2+}][F^{\ominus}]^2 =$

$(0.5 \times 10^{-2})(0.75 \times 10^{-2})^2$

$Q_{sp} > K_{sp}$. Hence precipitation occurs

$$[Ba^{2+}] = \frac{1.5\times10^{-3}}{2}, [F^{\ominus}] = \frac{10^{-2}}{2},$$

c. Q_{sp} of $BaF_2 = [Ba^{2+}][F^{\ominus}]^2 =$

$$\left(\frac{1.5 \times 10^{-3}}{2}\right)\left(\frac{10^{-2}}{2}\right)^2$$

$= 0.187 \times 10^{-7}$

$Q_{sp} < K_{sp}(0.187 \times 10^{-7} < 1.7 \times 10^{-7})$

So solution in (c) will not precipitate out

d. $[Ba^{2+}] = \frac{2\times10^{-2}}{2} = 10^{-2}$ M

$$[F^{\ominus}] = \frac{2 \times 10^{-2}}{2} = 10^{-2} \text{ M}$$

Q_{sp} $BaF_2 = (10^{-2})(10^{-2}) = 10^{-6}$

$\therefore Q_{sp} < K_{sp}$. Hence precipitation occurs

40 **(d)**

Effect of catalyst is only to alter the speed of the reaction, it does not effect the equilibrium constant and concentration of reactant or product

41 **(d)**

$$\alpha = 50\% = \frac{50}{100} = 0.5$$

$2HI \rightleftharpoons H_2 + I_2$

Initial $\quad 2 \quad 0 \quad 0$

Final $\quad (2 - 2\alpha) \quad \alpha \quad \alpha$

$$K=\frac{\alpha^2}{(2-2\alpha)^2}=\frac{0.5\times 0.5}{(2-2\times 0.5)^2}=0.25$$

42 **(a)**

$\mathrm{pH}=5.0, \mathrm{pOH}=11$

$\mathrm{pH}_1=5.0$, $[\mathrm{H_3O^{\oplus}}]=10^{-5}$ M.

New $\mathrm{pH}_2=2.0$, $[\mathrm{H_3O^{\oplus}}]=10^{-2}$ M.

Increase in concentration of $[\mathrm{H_3O^{\oplus}}]$

$$=\frac{10^{-2}}{10^{-5}}=10^3=1000\text{ times}$$

43 **(b)**

Buffer (A):

$$\mathrm{pH}_1=\mathrm{p}K_a+\log\left(\frac{x}{y}\right)\quad\ldots\text{(i)}$$

Buffer (B):

$$\mathrm{pH}_2=\mathrm{p}K_a+\log\left(\frac{x}{y}\right)\quad\ldots\text{(ii)}$$

Since $x>y$

$$\therefore \mathrm{pH}_1-\mathrm{pH}_2=1=\log\frac{x}{y}-\log\frac{y}{x}$$

$$\therefore 1=2\log\frac{x}{y}$$

$$\log\frac{x}{y}=\frac{1}{2}=0.5$$

$$\frac{x}{y}=\text{Antilog }(0.5)=3.17$$

44 **(b)**

NH_4OH is W_B

$$\therefore [\overset{\ominus}{\mathrm{O}}\mathrm{H}]=C\alpha=\sqrt{K_b\times c}=\sqrt{1.8\times 10^{-5}\times 0.1}$$

$$=1.34\times 10^{-3}\text{ M}$$

45 **(a)**

The equilibrium constant does not change at all with changes in concentrations, volume, pressure, presence of catalyst, etc. It changes only with changes in temperature of the system. For endothermic reaction, the value of K increases with increase in temperature and vice versa. For exothermic reaction, the value of K decreases with increase in temperature and vice versa

46 **(c)**

Salt of S_B/W_A are called acid salt

Na_2S, Na_2SO_4, Na_2SO_4 are salts of S_A/S_B. But $NaHSO_3$ is salt of W_A/W_B

47 **(b)**

Methyl orange gives red colour in acidic solution and yellow in basic solution

48 **(c)**

HA: $K_a=10^{-4}$

$HA+NaOH\rightleftharpoons NaA+H_2O$

Clearly, the reverse reaction is the hydrolysis reaction

$$\Rightarrow K_{\text{Required}}=\frac{1}{K_h}=\frac{K_a}{K_w}=\frac{10^{-4}}{10^{-14}}=10^{-10}$$

49 **(d)**

Since the given equilibrium involves $\Delta n_g=0$, there will be no effect of adding an insert gas and decreasing the volume of the container. A catalyst can help in achieving the equilibrium rapidly without affecting the equilibrium amounts of the species involved in the reaction

Only increasing the amount of a reactant can shift the equilibrium amount of a product

50 **(a)**

Salt of S_A/S_B do not hydrolysis in H_2O. So pH does not change on adding KCl to H_2O

51 **(b)**

$$\underset{}{\mathrm{Mg(OH)_2}}\longrightarrow \underset{S}{\mathrm{Mg^{2+}}}+\underset{2S}{2\overset{\ominus}{\mathrm{O}}\mathrm{H}}$$

Let S_1 is the solubility in 0.01 M $MgCl_2$ (common ion Mg^{2+})

$\therefore [\mathrm{Mg^{2+}}]=(S_1+0.01)\approx 0.01$

$[\overset{\ominus}{\mathrm{O}}\mathrm{H}]=2S_1$

$K_{sp}=(0.01)(2S_1)^2$

$$S_1=\left(\frac{K_{sp}}{4\times 0.01}\right)^{1/2}=\left(\frac{10^{-12}}{4\times 10^{-2}}\right)^{1/2}$$

$$=0.5\times 10^{-5}\text{ M}$$

$$\therefore [\overset{\ominus}{\mathrm{O}}\mathrm{H}]=2S_1=2\times 0.5\times 10^{-5}=10^{-5}\text{ M}$$

$\mathrm{pOH}=5, \mathrm{pH}=14-5=9$

52 **(a)**

$$[\mathrm{Pb(IO_3)_2}]\rightleftharpoons \underset{2S}{\mathrm{Pb^{2+}}}+\underset{S}{2\mathrm{IO_3^{\ominus}}}$$

$K_{sp}=4S^3$

$$S=\sqrt[3]{\frac{K_{sp}}{4}}=\sqrt[3]{\frac{3.2\times 10^{-14}}{4}}=2\times 10^{-5}\text{ M}$$

53 **(c)**

For $A \rightleftharpoons 2B$

Initial $1 \quad 0$

At Equilibrium $1-\alpha \quad 2\alpha$

Total moles $=1-\alpha+2\alpha=1+\alpha$

$\therefore P_A=$ (mole fraction of A) $\times$ Initial pressure

$=\left(\frac{1-\alpha}{1+\alpha}\right)P_1$

Similarly $P_B=\left(\frac{2\alpha}{1+\alpha}\right)P$

$$\therefore K_{p_1}=\frac{(P_B)^2}{(P_A)}=\frac{\left[\left(\frac{2\alpha}{1+\alpha}\right)P_1\right]^2}{\left(\frac{1-\alpha}{1+\alpha}\right)P_1}=\frac{4\alpha^2P_1}{(1-\alpha^2)}$$

For $P \rightleftharpoons Q + R$

Initial $1 \quad 0 \quad 0$

At Equilibrium $\quad 1-\alpha \quad \alpha \quad \alpha$

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

$$\therefore P_p = \left(\frac{1-\alpha}{1+\alpha}\right)P_2\ ;\ P_Q = \left(\frac{\alpha}{1+\alpha}\right)P_2\ ;$$

$$P_R = \left(\frac{\alpha}{1+\alpha}\right)P_2$$

$$K_{p_2} = \frac{P_R \times P_Q}{P_P} = \frac{\left(\frac{\alpha}{1+\alpha}\right)P_2 \times \left(\frac{\alpha}{1+\alpha}\right)P_2}{\left(\frac{1-\alpha}{1+\alpha}\right)P_2}$$

$$= \frac{\alpha^2 P_2}{(1-\alpha^2)}$$

$$\therefore \frac{K_{p_1}}{K_{p_2}} = \frac{2}{3}\,\text{(given)} = \frac{4\cancel{\alpha^2}P_1}{\cancel{(1-\alpha^2)}} \times \left(\frac{\cancel{1-\alpha^2}}{\cancel{\alpha^2}P_2}\right) = \frac{4P_1}{P_2}$$

$$\therefore \frac{P_1}{P_2} = \frac{1}{6}$$

54 **(c)**

pH = 10, pOH = 4, $[\overset{\ominus}{O}H] = 10^{-4}$ M.

$$Ba(OH)_2 \longrightarrow Ba^{2+} + 2\,\overset{\ominus}{O}H$$

$[\overset{\ominus}{O}H] = 10^{-4}$.

(Since total concentration of $\overset{\ominus}{O}H = 10^{-4}$)

$$\therefore K_{sp} = [Ba^{2+}][\overset{\ominus}{O}H]^2$$

$$10^{-9} = x \times (10^{-4})^2$$

$$\therefore x = 10^{-1} = [Ba^{2+}]$$

55 **(b)**

$$AgBr \longrightarrow Ag^{\oplus} + Br^{\ominus}$$

a. $NaBr \longrightarrow Na^{+} + Br^{\ominus}$

Due to common ion effect of $Br^{\ominus}$, solubility of AgBr will be less

$$NH_4OH \longrightarrow NH_4^{\oplus} + \overset{\ominus}{O}H$$

b. $Ag^{\oplus} + \overset{\ominus}{O}H \longrightarrow AgOH$

$\overset{\ominus}{O}H$ combines with $Ag^{\oplus}$ ions to give AgOH. So according to Le Chatelier's principle, reaction will proceed in forward direction and hence solubility of AgBr in H_2O will increase

c. Solubility of AgBr in H_2O will remain unaffected (here $\overset{\ominus}{O}H$ from water is very less i.e., $[\overset{\ominus}{O}H] = 10^{-7}$)

d. $HBr \longrightarrow H^{\oplus} + Br^{\ominus}$

So again due to common ion effect of $Br^{\ominus}$, solubility of AgBr will decrease

57 **(a)**

Use: $[H^{\oplus}]_{mix} = \sqrt{EK_{ai}C_i}$

$$= \sqrt{1.8 \times 10^{-4} \times 0.1 + 3.1 \times 10^{-4} \times 0.1}$$

$$= \sqrt{4.9 \times 10^{-5}}\ \text{M} = 7 \times 10^{-3}\ \text{M}$$

59 **(b)**

Factual statement

60 **(c)**

Largest pH, will be of the most basic solution, so $\frac{M}{10}$ NaOH, will have largest pH

61 **(c)**

Decrease or increase in the concentration of CO_2 does not effect pH

62 **(d)**

$$pH_1 = pK_a + \log\left(\frac{\text{Salt}}{\text{Acid}}\right)$$

$$pH_1 = pK_a + \log\left(\frac{x_1}{y_1}\right)$$

$$pH_2 = pK_2 + \log\left(\frac{x_2}{y_2}\right)$$

$$pH_2 - pH_1 = \log\frac{x_2}{y_2} - \log\frac{x_1}{y_1}$$

$$2 = \log\left(\frac{x_2/y_2}{x_1/y_1}\right)$$

$$\therefore \frac{x_2/y_2}{x_1/y_1} = 10^2 = 100$$

This is only possible, if the concentration of salt is increased by 10 times and the concentration of acid is decreased by 10 times

63 **(c)**

$$\underset{\text{Red}}{HIn} \xrightleftharpoons{K_{Ind}} H^{\oplus} + \underset{\text{Blue}}{Ind^{\ominus}}$$

Use: $pH = pK_{Ind} + \log\dfrac{[Ind^{\ominus}]}{[HIn]}$;

$$pK_{Ind} = -\log(3 \times 10^{-5}) = 4.52$$

$$75\%\ \text{Red} \Rightarrow \frac{[HIn]}{[Ind^{\ominus}]} = \frac{3}{1}$$

$$\Rightarrow pH = pK_{Ind} + \log\frac{1}{3} = 4.05$$

$$75\%\ \text{Blue} \Rightarrow \frac{[HIn]}{[Ind^{\ominus}]} = \frac{1}{3}$$

$$\Rightarrow pH = pK_{Ind} + \log\frac{3}{1} = 5.00$$

64 **(c)**

The hydrolysis reaction of conjugate base of acid is

$$A^-(aq) + H_2O \longrightarrow HO^- + HA$$

$$K_h = \frac{K_w}{K_a} = \frac{10^{-14}}{10^{-4}} = 10^{-10}$$

Since, degree of hydrolysis is negligible;

$$[OH^-] = \sqrt{K_h C} = 10^{-6}.p[OH] = 6$$

and $\quad$ pH=14-6=8

65 **(a)**

In which $\Delta n = 0$

i. $\Delta n = 2 - (1+1) = 0$

ii. $\Delta n = 2 - (2+1) = -1$

iii. $\Delta n = 2 - (1+3) = -2$

iv. $\Delta n = 1 - (1+1) = -1$

66 **(b)**

$HgCl_2 \rightleftharpoons Hg^{2+} + 2Cl^{\ominus}$

$\qquad\qquad 2S \qquad 2S$

$$S = \sqrt[3]{\frac{K_{sp}}{4}} = \sqrt[3]{\frac{4 \times 10^{-15}}{4}} = 10^{-5}$$

$\therefore 2S = 2 \times 10^{-5} = [Cl^{\ominus}]$

67 **(d)**

a. Acidic buffer, and have $pH < 7$

b. Also acidic buffer, $pH < 7$

c. Salt of W_A/W_B, $pH = 7$

d. Basic buffer, and $pH > 7$

68 **(d)**

$0.05\ M_{H_2SO_4} = 2 \times 0.05\ N_{H_2SO_4} = 0.1\ N$

$\therefore [H_3O^{\oplus}] = [0.1] = 10^{-1}$

$-\log [H_3O^{\oplus}] = -\log [10^{-1}] = 1$

$pH = 1$

69 **(b)**

Due to common ion $(NH_4^{\oplus})$, from NH_4Cl, it suppresses the ionization of NH_4OH, so as to give less concentration, of $\overset{\ominus}{OH}$ ions, so that only the hydroxides of III group can precipitate, not the hydroxides of higher group, since K_{sp} of the hydroxides of III group is lower than the K_{sp} of the hydroxides of higher group

70 **(a)**

In oxy acids of halogens, the higher the oxidation state of the halogen, the stronger the acid

The order of acidic strength is

$HClO_4 > HClO_3 > HClO_2 > HClO$

The order basic strength is

$ClO_4^{\ominus} < ClO_3^{\ominus} < ClO_2^{\ominus} < ClO^{\ominus}$

The stronger the acid, the weaker the conjugate base and vice versa

71 **(b)**

When equal volumes of $(NH_4Cl + NH_4OH)$ and metal ions are mixed (volume becomes double and concentration is halved)

$\therefore [\overset{\ominus}{OH}] = \frac{10^6}{2}$, $[M^{+n}] = \frac{0.1}{2}$

Q_{sp} (or IP) of metal hydroxides of $M(OH)_2$ type

$= [M^{+n}]\,[\overset{\ominus}{OH}]^2$

$= \left(\frac{0.1}{2}\right)\left(\frac{10^{-6}}{2}\right)^2 = \frac{1}{8} \times 10^{-13}$

$= 0.125 \times 10^{-13} = 12.5 \times 10^{-11}$

$\therefore Q_{sp} > K_{sp}$ of $Mg(OH)_2$ $(12.5 \times 10^{-11} > 3 \times$ $10-11$

And $Q_{sp} > K_{sp}$ of $Fe(OH)_2 (12.5 \times 10^{-11} > 8 \times 10^{-16})$

So both can be precipitated. Since the K_{sp} of $Fe(OH)_2$ is less than Ksp of $Mg(OH)_2$, so $Fe(OH)_2$ will be precipitated first

Similarly, Q_{sp} (or IP) of metal hydroxides of $M(OH)$ type

$= [M^{+1}]\,[\overset{\ominus}{OH}] = \left(\frac{0.1}{2}\right)\left(\frac{10^{-6}}{2}\right)$

$= 0.25 \times 10^{-7}$

$\therefore Q_{sp} < K_{sp}$ of AgOH $(0.25 \times 10^{-7} < 5 \times 10^{-3})$

It can not be precipitated out. Hence $Fe(OH)_2$ will be precipitated

72 **(e)**

$\qquad\qquad 2NO_2 \rightleftharpoons N_2O_4$

At equilibrium 0.2 kPa 0.4 kPa

$$K_p = \frac{[p_{N_2O_4}]}{[p_{NO_2}]^2} = \frac{0.4}{0.2 \times 0.2} = 10$$

73 **(a)**

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

a. With increase of temperature K_p increases, i.e; with increase of temperature, the reaction is favoured in forward direction and hence reaction is endothermic. Thus statement (a) is incorrect

b. Increase of temperature favours forward reaction and hence the formation of B increases. Correct statement

c. $\Delta n = 1 + 1 - 1 = 1$

$\Delta n = +ve$, i.e., with the increase of pressure, reaction is favoured backward direction and hence the formation of $A(g)$ increases. Correct statement

d. As from the above statement in (i) and (iii), the reaction is favoured backward with decrease of temperature and increase of pressure. Correct statement

74 **(b)**

a. 10^{-10} M HCl, since $[H_3O^{\oplus}] < 10^{-6}$M, so pH is less than 7 because of the acidic solution

b. 10^{-4} M NaOH, since

$[\overset{\ominus}{O}H] = 10^{-4}$ M, pOH = 4, pH = 10

c. 10^{-10}M NaOH, Since $[\overset{\ominus}{O}H] < 10^{-6}$ M, pH is slightly more than 7, because of the basic solution

75 **(a)**

On heating H_2O at 350 K, the self ionization of H_2O, increases

$$H_2O + H_2O \rightleftharpoons H_3O^{\oplus} + \overset{\ominus}{O}H$$

So the concentration of $[H_3O^{\oplus}]$ and $[\overset{\ominus}{O}H]$ both increases, so the pH increases or pOH decreases

76 **(c)**

For the weak acid HA,

$$K_a = \frac{[X^{\oplus}] \times [A^{\ominus}]}{[HA]}$$

Reaction of weak acid with strong base.

$$HA + OH^{\ominus} \rightleftharpoons A^{\ominus} + H_2O$$

$$K = \frac{[A^{\ominus}]}{[HA] \times [\overset{\ominus}{O}H]}$$

Dividing (1) by (2), we get

$$\frac{K_a}{K} = [H^{\oplus}]\,[\overset{\ominus}{O}H] = K_w$$

77 **(b)**

$A + B \rightleftharpoons C + D$

According to Le Chatelier's principle, as the concentration of the products are increased, the reaction proceeds in the backward direction

78 **(d)**

a. $HCl = 100 \times \frac{1}{10} = 10$ mEq

$NaOH = 100 \times \frac{1}{10} = 10$ mEq

Salt of S_A/S_B is formed, pH = 7

b. $HCl = 55 \times \frac{1}{10} = 5.5$ mEq

$NaOH = 45 \times \frac{1}{10} = 4.5$ mEq

1.0 mEq of HCl is left. So pH will be in acidic range but not equal to one, since concentration of HCl is very low

c. $HCl = 10 \times \frac{1}{10} = 1$ mEq

$NaOH = 90 \times \frac{1}{10} = 9$ mEq

8 mEq of NaOH is left and pH > 7

d. $HCl = 75 \times \frac{1}{5} = 15$ mEq

$NaOH = 25 \times \frac{1}{5} = 5$ mEq

15 − 5 = 10 mEq of HCl is left

$$\therefore [HCl] = [H_3O^{\oplus}] = \frac{10\text{ mEq}}{(75+25)\text{mL}} = \frac{10}{100} = 0.1\text{ M}$$

$pH = -\log(10^{-1}) = 1$

79 **(d)**

$$Fe^{3+}(aq) + H_2O(l) \rightleftharpoons Fe(OH)^{2+}(aq) + H_3O^{\oplus}(aq)$$

1 0 0

$C(1-\alpha)$ $C\alpha$ $C\alpha$

$$\left(1-\alpha = \frac{80}{100} = 0.8, \alpha = 0.2\right)$$

$$K_a = \frac{C\alpha}{1-\alpha}$$

$$6.5 \times 10^{-3} = \frac{C \times (0.2)^2}{0.8}. \ \therefore C = 13.0 \times 10^{-2}$$

$[H_3O^{\oplus}] = C\alpha = 13.0 \times 10^{-2} \times 0.2 = 26 \times 10^{-3}$

$pH = -\log(26 \times 10^{-3}) = -1.415 + 3 = 1.585$

$= 1.6$

81 **(d)**

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

$K_c = P_{CO_2}$, therefore, K_c only depends upon concentration of CO_2 as long as temperature remains constants and both $CaCO_3(s)$ and $CaO(s)$ are present

82 **(a)**

$N_2 + \ 3H_2 \rightleftharpoons 2NH_3$

30 30 0 initially

$(30-x)(30-x)$ $2x$ at equilibrium

$2x = 10 \ \therefore x = \frac{10}{2} = 5$

$N_2 = 30 - 5 = 25$ L

$H_2 = 30 - 3 \times 5 = 15$L

$NH_3 = 2 \times 5 = 10$L

83 **(b)**

An acid base indicator changes its colour when $pH = pK_a$ or $pOH = pK_b$

$\therefore K_b = 10^{-10}, pK_b = 10$

$\therefore pOH = 10, pH = 14 - 10 = 4$

pH = 4

84 **(b)**

The equilibrium constant depends only upon temperature

85 **(b)**

$H_2 + I_2 \rightleftharpoons 2HI$

Initial 1 1 0

Final $\frac{1-\alpha}{v}$ $\frac{1-\alpha}{v}$ $\frac{2\alpha}{v}$

Since $\Delta n = 0$ $[2-(1+1)]$

$\therefore K$ does not depend on volume

So on reducing volume to half K does not change
$\therefore K = 50$

86 **(a)**
Since all compounds (MA, MB, MC, and MD) are uni-univalent type. All will have the same formula of solubility in H_2O (i.e., $\sqrt{K_{sp}}$). Same concentration of common ion ($M^{\oplus}$) is added, so solubilities of all will be suppressed
Hence, the compound with least K_{sp} value will be precipitated, i.e., MA with $K_{sp} = 1.8 \times 10^{-10}$

87 **(a)**
Since K_{sp} of $CaCO_3$ and CaC_2O_4 are very close, so concentration of any species cannot be neglected
Let the solubilities of $CaCO_3$ and CaC_2CO_4 are x and y M

$$CaCO_3 \rightleftharpoons \underset{x}{Ca^{2+}} + \underset{x}{CO_3{}^{2-}}$$

$$CaC_2O_4 \rightleftharpoons \underset{y}{Ca^{2+}} + \underset{y}{CO_3{}^{2-}}$$

Total $[Ca^{2+}] = x + y$
K_{sp} of $CaCO_3 = [Ca^{2+}][CO_3{}^{2-}] = (x + y)x$
K_{sp} of $CaC_2O_4 = [Ca^{2+}][C_2O_4{}^{2-}] = (x + y)y$
$\therefore x(x + y) = 1.3 \times 10^{-9}$ ...(i)
$y(x + y) = 1.3 \times 10^{-9}$ ...(ii)

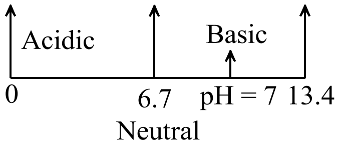
$$\frac{x}{y} = \frac{4.7 \times 10^{-9}}{1.3 \times 10^{-9}}$$

$\therefore x = 3.615y$
Substituting the value of x in equation (i) or (ii)
$3.615y(3.615y + y) = 4.7 \times 10^{-9}$
$3.615 \times 4.615y^2 = 4.7 \times 10^{-9}$

$$\therefore y = \left(\frac{4.7 \times 10^{-9}}{16.68}\right)^{1/2} = 1.67 \times 10^{-5}\ \text{M}$$

$x = 6.03 \times 10^{-5}$ M
$[Ca^{2+}] = x + y = (6.03 \times 10^{-5} + 1.67 \times 10^{-5})$
$= 7.707 \times 10^{-5}$M

88 **(b)**
$pK_w = 13.4$
If we calculate the pH of H_2O from the above value, it come to be 6.7. (Since conc. Of $H^{\oplus}$ and $\overset{\ominus}{OH}$ is equal). So new scale is made from 0 to 13.4



So, at pH = 7, Solution is basic

89 **(c)**
Let the initial concentration of $H^{\oplus} = 10^{-1}$M
pH = 1
the new concentration of $H^{\oplus}$, is 10 times the initial concentration of $H^{\oplus} = 10 \times 10^{-1}$ M $10^{\circ} = 1$
$pH_2 = -\log(1) = 0$
The change in pH $= pH_1 - pH_2 = 1.0 = 0$
Change in pH is one and it decreases from 1 to zero

90 **(b)**

$$\alpha = \frac{D - d}{d}$$

D = Vapour density before dissociation
d = Vapour density after dissociation
$N_2O_4 \rightleftharpoons 2NO_2$
Vapour density of N_2O_4 before dissociation

$$(D) = \frac{14 \times 2 + 16 \times 4}{2} = \frac{92}{2} = 46$$

Vapour density after dissociation (d) = 38.3

$$\therefore \alpha = \frac{46 - 38.3}{38.3} = 0.2$$

	N_2O_4	$\rightleftharpoons 2NO_2$
Initial	1	0
At equilibrium	$1 - \alpha$	2α

Number of moles of NO_2 at eq. $= 2\alpha = 2 \times 0.2 = 0.4$

91 **(b)**

	$2SO_3$	$\rightleftharpoons 2SO_2$	$+ O_2$
Initial	1	0	0
At equilibrium	$1 - 2x$	$2x$	x

$\therefore 2x = 0.6, \therefore x = 0.3$
$[SO_3] = 1 - 2x = 1 - 0.6 = 0.4$
$[SO_2] = 2x = 0.6$
$[O_2] = x = 0.3$

$$K = \frac{x \times (2x)^2}{(1 - 2x)^2} = \frac{0.3 \times 0.6 \times 0.6}{0.4 \times 0.4} = 0.675$$

92 **(d)**
$M_1V_2 = M_2V_2$
$10^{-5} \times 1 = M_2 \times 1000$
$M_2 = 10^{-8}$
$[H_3O^{\oplus}] = 10^{-8}$ M
Since the $[H_3O^{\oplus}] < 10^{-6}$
So pH ≈ 6.98

93 **(c)**

	N_2O_4	$\rightleftharpoons 2NO_2$
Initial	1	0
Final	$1 - \alpha$	2α

[Total moles $= 1 - \alpha + 2\alpha = 1 + \alpha$]
Partial pressure $\frac{1-\alpha}{1+\alpha} \times P$ $\frac{2\alpha}{1+\alpha} \times P$
Given, $\alpha = 0.2, P = 1$
Partial pressure of $N_2O_4 = \frac{1-0.2}{1+0.2} \times 1 = \frac{0.8}{1.2} = \frac{2}{3}$

$$p_{\mathrm{NO_2}} = \frac{2\times 0.2}{1+0.2}\times 1 = \frac{0.4}{1.2} = \frac{1}{3}$$

$$K_p = \frac{[p_{\mathrm{NO_2}}]^2}{[p_{\mathrm{N_2O_4}}]} = \frac{1\times 1\times 3}{3\times 3\times 2} = \frac{1}{6}$$

94 **(c)**

Find the $[\mathrm{Ag}^{\oplus}]$ in all the saturated solutions

$[\mathrm{Ag}^{\oplus}]_{\text{in AgCl}} = \sqrt{K_{\mathrm{sp}}\ \mathrm{AgCl}} = \sqrt{1.8\times 10^{-10}}$ M;

$[\mathrm{Ag}^{\oplus}]_{\text{in AgBr}} = \sqrt{K_{\mathrm{sp}}\ \mathrm{AgBr}} = \sqrt{5.0\times 10^{-13}}$ M

$$[\mathrm{Ag}^{\oplus}]_{\text{in Ag}_2\text{CrO}_4} = 2\sqrt[3]{\frac{K_{\mathrm{sp}}\ \mathrm{Ag_2CrO_4}}{4}}$$

$$= 2\sqrt[3]{\frac{2.4\times 10^{-12}}{4}}\ \mathrm{M}$$

$\Rightarrow [\mathrm{Ag}^{\oplus}]$ is maximum in saturated solution of $\mathrm{Ag_2CrO_4}$

95 **(d)**

Salt of W_A/S_B hydrolyse and the solution is basic, i.e., pH > 7

$$\mathrm{pH} = \frac{1}{2}(\mathrm{p}K_w + \mathrm{p}K_a + \log C)$$

96 **(b)**

$\mathrm{M_2X}$: Solubility of $\mathrm{M_2X} = \sqrt[3]{\frac{K_{\mathrm{sp(M_2X)}}}{4}}$

MX: Solubility of MX $= \sqrt{K_{\mathrm{sp(MX)}}}$

$\mathrm{MX_3}$: Solubility of $\mathrm{MX_3} = \sqrt[4]{\frac{K_{\mathrm{sp(MX_3)}}}{27}}$

Clearly, solubility is maximum for $\mathrm{MX_3}$ and then $\mathrm{M_2X}$

97 **(a)**

Let the solubility by S

$$\mathrm{A}_p\mathrm{B}_q \rightleftharpoons \underset{pS}{p\mathrm{A}^{\oplus}} + \underset{qS}{q\mathrm{B}^{\ominus}}$$

$K_{\mathrm{sp}} = [\mathrm{A}^{\oplus}]^p \times [\mathrm{B}^{\ominus}]^q$

$= [pS]^p \times [qS]^q$

$= p^p \times q^q \times S^{p+q}$

98 **(c)**

i. $\mathrm{AgCl + H_2O \longrightarrow Ag^{\oplus}(aq) + Cl^{\ominus}(aq)}$ ...S_1

ii. AgCl in 0.01 M $\mathrm{CaCl_2}$, ...S_2

Concentration of $\mathrm{Cl}^{\ominus} = 2\times 0.01 = 0.02$ M

iii. AgCl in 0.01 M NaCl ...S_3

Concentration of $\mathrm{Cl}^{\ominus} = 0.01$ M

iv. AgCl is 0.05 M, $\mathrm{AgNO_3}$, ...S_4

Concentration of $\mathrm{Ag}^{\oplus} = 0.05$

Since both $\mathrm{Cl}^{\ominus}$ ion and $\mathrm{Ag}^{\oplus}$ ions acts as common ion. So larger the concentration of $\mathrm{Ag}^{\oplus}$ or $\mathrm{Cl}^{\ominus}$ ions, more is the suppression of ionization of AgCl and hence less will be solubility of AgCl

∴ Solubility order

$S_1 > S_3 > S_2 > S_4$

99 **(b)**

$[\mathrm{H_3O}^{\oplus}] = 10^{-6} = [\overset{\ominus}{\mathrm{O}}\mathrm{H}]$

Because in pure water, $[\mathrm{H_3O}^{\oplus}] = [\overset{\ominus}{\mathrm{O}}\mathrm{H}]$

$K_w = [\mathrm{H_3O}^{\oplus}] = [\overset{\ominus}{\mathrm{O}}\mathrm{H}]$

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

$= 10^{-12}$

100 **(a)**

$$\mathrm{FeO(s) + CO(g) \rightleftharpoons Fe(s) + CO_2(g)}$$

At eq. — 0.025 — x

solid solid

$$K_c = \left[\frac{\mathrm{CO_2(g)}}{\mathrm{CO(g)}}\right] = \frac{x}{0.025} = 5.0(\text{Given})$$

∴ x = 0.125 M

$[\mathrm{CO_2}] = 0.125$ M

101 **(d)**

At equilibrium, amount of $\mathrm{NH_3}$ formed is equal to the amount of $\mathrm{NH_3}$ decomposed into $\mathrm{H_2}$ and $\mathrm{N_2}$

102 **(c)**

$A + 2B \rightleftharpoons C + \text{Heat}$

The equation shows, that it is exothermic reaction. Since the heat is released in the reaction, so the reaction is favoured in forward direction at low temperature

$\Delta n = 1 - (2+1) = -2$

Since the number of moles decreases, ∴ the forward reaction is favoured at high pressure

103 **(c)**

K does not depend on initial concentration of R or P

104 **(d)**

Weak monoacidic base *e.g.*, BOH is neutralised as follows

$$B\mathrm{OH} + \mathrm{HCl} \rightarrow B\mathrm{Cl} + \mathrm{H_2O}$$

At equivalence point all BOH gets converted into salt and remember! The concentration of H^+ (or pH of solution) is due to hydrolysis of resultant salt (BCl, cationic, hydrolysis here)

$$\underset{C(1-h)}{\mathrm{B}^+} + \mathrm{H_2O} \rightleftharpoons \underset{Ch}{\mathrm{BOH}} + \underset{Ch}{\mathrm{H}^+}$$

Volume of HCl used up

$$V_a = \frac{N_bV_b}{N_a} = \frac{2.5\times 2\times 15}{2\times 5} = 7.5\ \mathrm{mL}$$

Concentration of salt

$$[\mathrm{BCl}] = \frac{\text{conc.of base}}{\text{total volume}} = \frac{2\times2.5}{5(7.5+2.5)} = \frac{1}{10} = 0.1$$

$$K_h = \frac{Ch^2}{1-h} = \frac{K_w}{K_b}$$

(h should be estimated whether that can be neglected or not)

on calculating h=0.27 (significant, not negligible)

$[\mathrm{H}^+] = Ch = 0.1 \times 0.27 = 2.7 \times 10^{-2}\mathrm{M}$

105 **(b)**

$N_2O_4 \rightleftharpoons 2NO_2$

1 0

$(1 - 0.2)$ $2 \times 0.2 = 0.4$

Total pressure = 1.2

As the temperature is doubled, the pressure becomes double. Therefore, the total final pressure is $1.2 \times 2 = 2.4$ atm

106 **(c)**

With increase in temperature, K value decreases, which means that at high temperature the reaction proceeds in backward direction or proceeds forward at room temperature. In another words, at room temperature, HI dissociates or HI is less stable than H_2 and I_2

109 **(b)**

Only salts of S_A/S_B do not hydrolyse while all other salts hydrolyse

NaCl, KCl, Na_2SO_4 are salts of S_A/S_B, so do not hydrolyse but NH_4Cl_3 is salt of W_A/S_B and hydrolyses

110 **(c)**

Lewis acid is that which is e^- deficient and can accept lone pair of e^- s. So BF_3 can accept a lone pair of e^-s

111 **(d)**

For the reaction $A + B \rightarrow C + D$, the reaction quotient is defined as

$$Q = \frac{[C][D]}{[A][B]}$$

In the initial stages of the reaction, the concentrations of C and D increase while those of A and B decrease. Hence, the value of Q increases with time

112 **(c)**

The aqueous solution of KCN, K_2CO_3 and LiCN turn red litmus blue because of alkaline nature.

The anionic hydrolysis turns the solution alkaline.

113 **(a)**

Similarly like in problem 102(above), $NaNO_3$, KCl and K_2SO_4 are salts of S_A/S_B and do not hydrolyse. But CH_3COOK is a salt of W_A/W_B and hydrolyses

114 **(b)**

Factual statement

115 **(d)**

Reaction quotient is equal to the ratio of the concentrations of products to the ratio of the concentrations of the reactants at any stage of the reaction, each concentration term being raised to the power of its stoichiometric coefficient. In the beginning of the reaction, $Q = 0$

As the reaction proceeds in the forward direction, Q starts increasing

At chemical equilibrium, $Q = K$

116 **(d)**

$Ba(OH)_2 > Ca(OH)_2 > Mg(OH)_2 > Be(OH)_2$

In alkaline earth metal hydroxides, the solubility increases down the group

117 **(b)**

$H_3O^{\oplus} = 10^{-9}$ M

Since the concentration of $H_3O^{\oplus}$ is $< 10^{-6}$ M. So concentration of $H_3O^{\oplus}$ is calculated from ionization of water and its common effect, so the value will lie between 6 and 7

118 **(b)**

$CH_3COOH \rightarrow CH_3COO^{\ominus} + H^{\oplus}$

Only the HCl provides common ion $H^{\oplus}$ and so it will suppress the ionization of acetic acid

119 **(d)**

$XY(g) \rightleftharpoons X(g) + Y(g)$

Initial 1 0 0.2

At eq. $1 - x$ x $0.2 + x$

At eq. $[X] = 0.2 + x = 0.6$

$$\therefore x = 0.4 \text{ mol } = \frac{0.4}{1} = 0.4 \text{ M}$$

$$[XY] = 1 - 0.4 \text{ mol} = 0.6 \text{ mol} = \frac{0.6}{1} = 0.6 \text{ M}$$

$$[X] = x = 0.4 = \frac{0.4}{1} = 0.4 \text{ M}$$

$$K = \frac{[X][Y]}{[XY]} = \frac{0.4 \times 0.6}{0.6} = 0.4 \text{ mol L}^{-1}$$

120 **(a)**

Equilibrium is affected by changes in concentrations, temperature, pressure, and volume. It is not affected by the presence of a catalyst. The presence of a catalyst just helps to achieve the equilibrium at a different pace. It does not affect the amount of a reactant or a product at equilibrium

121 **(c)**

$K_w = [H_3O^{\oplus}][\overset{\ominus}{O}H]$

$= 10^{-6.7} \times 10^{-6.7} = 10^{-13.4}$

122 **(a)**

Stronger is the acid, weak is the conjugate base and vice versa

Base	**Acid**
$ClO^{\ominus}$	$HClO$
$ClO_2^{\ominus}$	$HClO_2$
$ClO_3^{\ominus}$	$HClO_3$
$ClO_4^{\ominus}$	$HClO_4$

Acidic order: $HClO_4 > HClO_3 > HClO_2 > HClO$

Conjugate base order: $ClO_4^{\ominus} < ClO_3^{\ominus} < ClO_2^{\ominus} < ClO^{\ominus}$

∴ Strongest base = $ClO^{\ominus}$

123 **(c)**

$W + X \rightleftharpoons Y + Z, \quad K = 9$

Initial $1 \quad 1 \quad 0 \quad 0$

At eq. $1-x \quad 1-x \quad x \quad x$

$$K = 9 = \frac{x^2}{(1-x)^2}$$

$\therefore x = 0.75$

Moles of $y = x = 0.75$

124 **(c)**

$$\alpha = \frac{1}{100} = 10^{-2}$$

$BOH \rightleftharpoons B^{\oplus} + \overset{\ominus}{O}H$

$$K_b = \frac{C\alpha^2}{1-\alpha} \approx C\alpha^2 = 0.1 \times (10^{-2})^2 = 10^{-5}$$

When 0.2 mol of BCl is added, due to common ion effect of $B^{\oplus}$ $(BCl \rightleftharpoons B^{\oplus} + Cl^{\ominus})$, suppression of ionization of BOH occurs, and α becomes α'

$\therefore \ \alpha' = \frac{K_b}{M}$ (M = molarity of common ion added)

$$= \frac{10^{-5}}{0.2} = 5 \times 10^{-5}\ \text{M}$$

125 **(c)**

$AgCl \rightleftharpoons \underset{x}{Ag^{\oplus}} + \underset{x}{Cl^{\ominus}}$

$NaCl \longrightarrow Na^{\oplus} + Cl^{\ominus}$

Initial $0.1 \quad 0 \quad 0$

Final $0 \quad 0.1 \quad 0.1$

(NaCl is a salt of S_A/S_B, which is completely ionised)

∴ $Cl^{\ominus} = (x + 0.1) \approx 0.1$ (Since x is very small)

∴ $K_{sp} = [Ag^{\oplus}][Cl^{\ominus}]$

$1.2 \times 10^{-10} = x \times 0.1$

$$x = \frac{1.2 \times 10^{-10}}{0.1} = 1.2 \times 10^{-9}\ \text{M}$$

126 **(d)**

i. K_2SO_4 is salt of S_A/S_B and do not hydrolyse so pH = 7

ii. pH of pure H_2O = 7

iii. pH of 10^{-2} mols of HCl per litre = 2

iv. pH of weak bae NH_4OH will be more than 7

127 **(a)**

$N_1V_1(\text{HCl}) = N_2V_2(\text{NaOH})$

$x \times 20 = 40 \times 0.05$

$x = 0.1$

∴ M of HCl = 0.1

$[H_3O^{\oplus}] = 0.1 = 10^{-1}$

pH = 1

128 **(b)**

$A + B \rightleftharpoons C + D$

Initial $4 \quad 4 \quad 0 \quad 0$

Final $4-x \quad 4-x \quad x \quad x$

$x = 2$

$\therefore [A] = 4 - 2 = 2, \quad [B] = 4 - 2 = 2$

$[C] = 2, \quad [D] = 2$

$$K = \frac{[C][D]}{[A][B]} = \frac{2 \times 2}{2 \times 2} = 1$$

129 **(b)**

If forms basic buffer

$$\text{pOH} = \text{p}K_b + \log\left(\frac{2.5/500}{2.5/500}\right) = 4.7$$

pH = 14 − 4.7 = 9.3

130 **(b)**

$XY_2 \rightleftharpoons XY + Y$

Initial $P \quad 0 \quad 0$

Final $P-x \quad x \quad x$

Initial P = 600 mm Hg, Final P = 800 mm Hg

Total moles ∝ final P

$\therefore P - x + x + x \propto 800$

$600 - x + x + x \propto 800$

$x = 200$ mm Hg

$$K = \frac{x \times x}{P - x} = \frac{200 \times 200}{400} = 100\ \text{Hg}$$

131 **(a)**

$HA + H_2O \rightleftharpoons H_3O^{\oplus} + A^{\ominus}$

Initial $1 \quad 0 \quad 0 \quad 0$

Final $C(1-\alpha) \quad C\alpha \quad C\alpha$

$[H_3O^{\oplus}] = C\alpha = 0.1 \times 0.01 = 10^{-3}$

pH = 3, pOH = 11

132 **(b)**

$CO_2 \rightleftharpoons CO + \frac{1}{2} O_2$

Initial $1 \quad 0 \quad 0$

Final $1-\alpha \quad \alpha \quad \alpha/2$

Final $4(1-\alpha) \quad 4\alpha \quad \alpha/2 \times 4$

$\alpha = 0.25\% = 0.25$

Number of moles of CO $= 4\alpha = 4 \times 0.25 = 1$

133 **(d)**

mEq of $CH_3COOH = 20 \times \frac{1}{10} = 2$

mEq of $NaOH = 16 \times \frac{1}{10} = 1.6$

So 1.6 mEq of NaOH reacts with 1.6 mEq of CH_3COOH to form 1.6 mEq of salt CH_3COONa and $(2 - 1.6 = 0.4$ mEq) of $W_A(CH_3COOH)$ is left and an acidic buffer is formed. So to calculate pH, buffer equation is used

$$\text{pH} = \text{p}K_a + \log\left(\frac{\text{Salt}}{\text{Acid}}\right) = 4.74 + \log\left(\frac{1.6}{0.4}\right)$$

$= 4.74 + 2\log 2$

$= 4.74 + 2 \times 0.3010 = 5.35$

134 **(d)**

pH = 2, ∴ $[H_3O^{\oplus}] = 10^{-2}$ M

pH = 6, ∴ $[H_3O^{\oplus}] = 10^{-6}$ M

$\therefore \frac{10^{-2}}{10^{-6}} = 10^{-4}$

135 **(d)**

$Ca_3(PO_4)_2 \rightleftharpoons 3Ca^{2+} + 3PO_4^{3-}$

$3x \qquad 3x$

$K_{\text{sp}} = (3x)^3(2x)^2 = 108x^5$

∴ Unit of K_{sp} is (concentration)^5 =

$(\text{mol dm}^{-3})^5 = \text{mol}^5\ \text{dm}^{-15} = \text{mol}^5\ \text{dm}^{-15}$

136 **(c)**

Since there is no effect on the equilibrium by adding inert gas at constant volume

138 **(b)**

$N_2O_4 \rightleftharpoons 2NO_2$

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

Number of moles of $N_2O_4 = 1 - \alpha = 1 - 0.2 = 0.8$

Weight of N_2O_4 in mixture

= moles of $N_2O_4 \times Mw$ of $N_2O_4 = 0.8 \times 92 =$ 73.6 g

Weight of NO_2 in mixture = moles of $NO_2 \times Mw$ of NO_2

$= 0.4 \times 46 = 18.4$ g

Total weight $= 73.6 + 18.4 = 92.0$ g

In 92 g of mixture, number of moles of $N_2O_4 = 0.8$

In 100 g of mixture; number of moles of N_2O_4

$= \frac{0.8 \times 100}{92} = 0.86$

139 **(c)**

Bronsted acid and base is that which can donate and accept $H^{\oplus}$ ions. So $HSO_4^{\ominus}$ can accept and donate $H^{\oplus}$ ions

140 **(b)**

For reactions $\quad X \rightleftharpoons 2Y$

Initial $\quad 1 \qquad 0$

At Equilibrium $\quad 1 - \alpha \qquad 2\alpha$

Total moles $= 1 - \alpha + 2\alpha = 1 + \alpha$

$P_X = \left(\frac{1-\alpha}{1+\alpha}\right)P_1$; $P_Y = \left(\frac{2\alpha}{1+\alpha}\right)P_1$

$\therefore K_{p_1} = \frac{(P_Y)^2}{P_X} = \frac{\left[\left(\frac{2\alpha}{1+\alpha}\right)P_1\right]^2}{\left(\frac{1-\alpha}{1+\alpha}\right)P_1} = \frac{4\alpha^2P_1}{(1-\alpha^2)}$ ....(i)

Similarly for $\quad X \rightleftharpoons P + Q$

Initial $\quad 1 \qquad 0 \qquad 0$

At Equilibrium $1 - \alpha \quad 2\alpha \quad \alpha$

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

$P_Z = \left(\frac{1-\alpha}{1+\alpha}\right)P_2$; $P_Q = \left(\frac{\alpha}{1+\alpha}\right)P_2$;

$P_P = \left(\frac{\alpha}{1+\alpha}\right)P_2$

$$\therefore K_{p_2} = \frac{P_P \times P_Q}{P_Z} = \frac{\left(\frac{\alpha}{1+\alpha}\right)P_2 \times \left(\frac{\alpha}{1+\alpha}\right)P_2}{\left(\frac{1-\alpha}{1+\alpha}\right)P_2}$$

$= \frac{\alpha^2P_2}{(1-\alpha^2)}$ ... (ii)

Dividing equation (i) and (ii), we get,

$\frac{K_{p_1}}{K_{p_2}} = \frac{4\alpha^2P_1}{(1-\alpha^2)} \times \left(\frac{1-\alpha^2}{\alpha^2P_2}\right) = \frac{4P_1}{P_2}$

$\Rightarrow \frac{4P_1}{P_2} = \frac{1}{3}$ (given)

$\therefore \frac{P_1}{P_2} = \frac{1}{12}$

141 **(a)**

$HA + H_2O \rightleftharpoons H_3O^{\oplus} + A^{\ominus}$

Initial $\quad 1 \qquad 0 \qquad 0 \qquad 0$

Final $\quad C(1-\alpha) \qquad C\alpha \qquad C\alpha$

$[H_3O^{\oplus}] = C\alpha \left(\alpha = \frac{40}{100} = 0.4\right)$

$= 0.2 \times 0.4 \quad (C = 0.2$ M)

$= 0.08$

142 **(c)**

NaZ is salt of W_A/S_B

$\therefore \text{pH} = \frac{1}{2}(\text{p}K_w + \text{p}K_a + \log C)$

$8.9 \times 2 = 14 + \text{p}K_a + \log 0.1$

$17.8 = 14 + \text{p}K_a - 1$

$\text{p}K_a = 4.8,$

K_a = Antilog (-4.8) = Antilog $(-4 - 0.8 + 1 - 1)$

= Antilog $(\bar{5}.2) = 1.585 \times 10^{-5} \approx 1.6 \times 10^{-5}$

143 **(a)**

With the increase of temperature, k value decreases, so the forward reaction decreases with increase of temperature. This implies that reaction will proceed in forward direction with decrease of temperature, i.e., heat is liberated and hence forward reaction is exothermic

144 **(d)**

$\mathrm{NH_4} \quad + \quad \mathrm{NaOH} \rightarrow \mathrm{NH_4OH} + \mathrm{NaCl}$

mmol $50 \times 0.2 \quad 75 \times 0.1$

$= 10 \quad = 7.5$

mmol $10 - 7.5 \quad - \quad 7.5$

$= 2.5$

$\Rightarrow$ This will result in a basic buffer

$\Rightarrow \mathrm{pOH} = \mathrm{p}K_b + \log \dfrac{[\mathrm{Salt}]}{[\mathrm{Base}]}$

$= 4.74 + \log \dfrac{2.5}{2.5} = 4.27$

$\Rightarrow \mathrm{pH} = 14 - 4.27 = 9.73$

146 **(a)**

$\mathrm{CaF_2} \rightleftharpoons \mathrm{Ca^{2+}} + 2\mathrm{F^{\ominus}}$

$x \qquad 2x$

Total concentration of $[\mathrm{F^{\ominus}}] = 4 \times 10^{-4}$ M

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

$x = 2 \times 10^{-4}$

$\therefore K_{\mathrm{sp}} = 4x^3 = 4 \times (2 \times 10^{-4})^3 = 3.2 \times 10^{-11}$

147 **(d)**

i. $\mathrm{Ag_2CrO_4} \rightleftharpoons 2\mathrm{Ag^{\oplus}} + \mathrm{CrO_4^{2-}}$ (in $\mathrm{H_2O}$)

$2S \qquad S$

$4S^3 = K_{\mathrm{sp}};$

$S_{\mathrm{H_2O}} = \left(\dfrac{K_{\mathrm{sp}}}{4}\right)^{1/3} = \left(\dfrac{9 \times 10^{-12}}{4}\right)^{1/3}$

$= (2.25)^{1/3} \times 10^{-4}$ M

ii. On adding 0.1 M $\mathrm{AgNO_3}$

$(\mathrm{AgNO_3} \longrightarrow \mathrm{Ag^{\oplus}} + \mathrm{NO_3})$

0.1 M 0.1 M

Due to common ion ($\mathrm{Ag^{\oplus}}$), the solubility of $\mathrm{Ag_2CrO_4}$ is suppressed

Total $[\mathrm{Ag^{\oplus}}] = (2S + 0.1) \approx 0.1$

Let the solubility is S_1

$\therefore S_1 = \dfrac{K_{\mathrm{sp}}}{[\mathrm{Ag^{\oplus}}]^2 \text{ externally added}}$

$= \dfrac{9 \times 10^{-12}}{0.1 \times 0.1} = 9 \times 10^{-10}$ M

iii. On adding 0.1 M $\mathrm{Na_2CrO_4}$

$(\mathrm{Na_2CrO_4} \longrightarrow 2\mathrm{Na^{\oplus}} \quad + \quad \mathrm{CrO_4^{2-}})$

2×0.1 M $\qquad$ 0.1 M

Again due to common ion ($\mathrm{CrO_4^{2-}}$), the solubility of $\mathrm{Ag_2CrO_4}$ is suppressed

Let the solubility is S_2

Total $[\mathrm{CrO_4^{2-}}] = (S + 0.1) \approx 0.1$

$\mathrm{Ag_2CrO_4} \rightleftharpoons 2\mathrm{Ag^{\oplus}} + \mathrm{CrO_4^{2-}}$

$2S_2 \qquad (S_2 + 0.1) \approx 0.1$

$K_{\mathrm{sp}} = [2S_2]^2[0.1]$

$\therefore S - 2 = \left(\dfrac{K_{\mathrm{sp}}}{4 \times 0.1}\right)^{1/2} = \left(\dfrac{9 \times 10^{-12}}{4 \times 0.1}\right)^{1/2}$

$= 22.5 \times 10^{-6} = 2.25 \times 10^{-7}$

Hence, the solubility order is II < III < I

Note: *In such problems, instead of solving the exact value, try to get the approximate data to check the comparative solubilities*)

148 **(d)**

Anionic hydrolysis is carried by salt of W_A/S_B, e.g., $\mathrm{Na_2CO_3}$

150 **(b)**

Most soluble compound is that which have highest K_{sp} value. K_{sp} of $\mathrm{MnS}(7 \times 10^{-6})$ is highest

151 **(c)**

Volume = 3 L

$\mathrm{X} + \mathrm{Y} \rightleftharpoons 3\mathrm{Z}$

At eq. $\dfrac{1}{3} \quad \dfrac{2}{3} \quad \dfrac{4}{3}$

$K = \dfrac{[Z]^3}{[X][Y]} = \dfrac{\left(\frac{4}{3}\right)^3}{\left[\frac{2}{3}\right]\left[\frac{1}{3}\right]} = 10.67$

a. $Q = 10, \quad \therefore Q < K$

The reaction proceed forward direction to attain the equilibrium value of K

b. $Q = 15, \quad \therefore Q < K$

The reaction proceed backward direction to attain the equilibrium value of $K(10.67)$

c. $Q = 10.67, \quad \therefore Q = K$

The system is at equilibrium

152 **(b)**

Buffer solution is a mixture of

W_A + salt of W_A/S_B

Or a mixture of W_B + Salt of W_B/S_A

So ($\mathrm{NaH_2PO_4} + \mathrm{Na_2HPO_4}$) is a buffer

a. [HCl + NaCl,] $\quad S_A$ + Salt of S_A/S_B (not buffer)

b. [$\mathrm{NaH_2PO_4} + \mathrm{Na_2HPO_4}$] $\quad W_A$ + Salt of W_A/W_B (it is a buffer)

c. [$\mathrm{CH_3COOH}$ + NaCl] $\quad W_A$ + Salt of S_A/S_B (not buffer)

d. [$\mathrm{NH_4OH} + \mathrm{NH_3}$] $\quad W_B + W_B$ (not buffer)

153 **(b)**

$A + 2B \rightleftharpoons 2C$, ...(i) $K = 40$

and for $C \rightleftharpoons B + \frac{1}{2}A$, ... (i) $K_1 = ?$

$K = \dfrac{1}{\sqrt{K}} = \dfrac{1}{(40)^{1/2}}$

Since equation (2) is obtained by reversing and dividing by 2, the equation (1)

154 **(a)**

$$Ag_2SO_4 \rightleftharpoons 2Ag^{\oplus} + SO_4^{2-}$$
$$\quad\quad\quad 2x \quad\quad x$$
$K_{\text{sp}} = 4x^3 = 4 \times (2.5 \times 10^{-2})^3 = 62.5 \times 10^{-6}$

155 **(d)**

$M_2SO_4 \rightleftharpoons 2M^{\oplus} + SO_4^{2-}$

$\quad\quad\quad 2S \quad\quad S$

$K_{\text{sp}} = (2S)^2(S) = 4S^3$

$\therefore S = \sqrt[3]{\frac{K_{\text{sp}}}{4}} = \sqrt[3]{\frac{3.2 \times 10^{-5}}{4}} = 2 \times 10^{-2}\ \text{M}$

156 **(d)**

Only in $SnCl_4$, the octet of the central atom is complete

157 **(a)**

NaCl is salt of S_A/S_B. So it is neutral and $\text{pH} = 7$

158 **(a)**

$W_A(CH_3COOH)$ is titrated with S_B (NaOH) and 20% of the W_A is neutralized, so 20% of the salt of W_A/S_B (CH_3COONa) is formed and 80% of the $W_A(CH_3COOH)$ is left. So an acidic buffer if formed

$\therefore [\text{Acid}] = 80; [\text{Salt}] = 20$

$\text{pH} = \text{p}K_a + \log\left[\frac{\text{Salt}}{\text{Acid}}\right]$

$4.7447 + \log\left[\frac{\text{Salt}}{\text{Acid}}\right]$

$= 4.7447 + \log\frac{1}{4}$

$= 4.7447 - 2\log 2 = 4.7447 - 2 \times 0.3010 = 4.14$

159 **(b)**

Since K_{sp} of $CaCO_3$ and $BaCO_3$ are very close. So concentration of any species cannot be neglected. Let the solubility of $CaCO_3$ and $BaCO_3$ are x and y M

$\therefore CaCO_3 \rightleftharpoons Ca^{2+} + CO_3{}^{2-}$

$\quad\quad\quad\quad x \quad\quad x$

$BaCO_3 \rightleftharpoons Ba^{2+} + CO_3{}^{2-}$

$\quad\quad\quad\quad y \quad\quad y$

Total $[CO_3{}^{2-}] = (x + y)$

$\therefore K_{\text{sp}}$ of $CaCO_3 = [Ca^{2+}][CO_3{}^{2+}] = x(x + y)$

K_{sp} of $BaCO_3 = [Ba^{2+}][CO_3{}^{2-}] = y(x + y)$

$\therefore x(x + y) = 10^{-8}$ ...(i)

$y(x + y) = 5 \times 10^{-9}$ ...(ii)

$\frac{5 \times 10^{-9}}{10^{-8}} = \frac{y(x + y)}{x(x + y)}$

$\therefore \frac{y}{x} = 5 \times 10^{-1}$

$y = 0.5x$

Substitute the value of y in (i) or (ii)

$x(x + 0.5x) = 10^{-8}$

$x = 0.8 \times 10^{-4}$

$y = 0.5 \times 0.8 \times 10^{-4}$

$\therefore [Ca^{2+}] = x = 0.8 \times 10^{-4}$

$\therefore [Ba^{2+}] = y = 0.4 \times 10^{-4}$

$[CO_3{}^{2-}] = (x + y) = 1.2 \times 10^{-4}$

160 **(d)**

The equilibrium constant does not change at all with changes in concentrations, volume, pressure, presence of catalyst, etc. It changes only with changes in temperature of the system. For endothermic reaction, the value of K increases with increase in temperature and vice versa. For exothermic reaction, the value of K decreases with increase in temperature and vice versa

161 **(a)**

Bronsted acid is which gives $H^{\oplus}$ ions and Bronsted base is which accepts $H^{\oplus}$ ion

So H_2S gives $H^{\oplus}$ ions but cannot accept $H^{\oplus}$. While other $H_2O, HCO_2{}^{\ominus}, NH_3$ can give and accept $H^{\oplus}$ ions

162 **(a)**

Since equal volumes are added

1. Ionic product $= \frac{10^{-4}}{2} \times \frac{10^{-4}}{2} = \frac{10^{-8}}{4}$
2. Ionic product $= \frac{10^{-5}}{2} \times \frac{10^{-5}}{2} = \frac{10^{-10}}{4}$
3. Ionic product $= \frac{10^{-5}}{2} \times \frac{10^{-6}}{2} = \frac{10^{-11}}{4}$
4. Ionic product $= \frac{10^{-10}}{2} \times \frac{10^{-10}}{2} = \frac{10^{-20}}{4}$

Only in (a) Ionic product $\left(\frac{10^{-8}}{4}\right) > K_{\text{sp}}\ (1.8 \times 10^{-10})$

So precipitate will take place only with (a)

163 **(a)**

Since $Ca(OH)_2$ is completely ionized

$$Ca(OH)_2 \longrightarrow Ca^{2+} + 2\overset{\ominus}{O}H$$

Initial 0.1 0 0

Final 0 0.1 $2 \times 0.1 = 0.2$M

BBB Rule: On adding base, to the basic buffer, concentration of base increases and salt decreases

$\therefore$ New concentration of base and salt are:

$[\text{Base}] = [NH_3] = 0.6 + 0.2 = 0.8$ M

$[\text{Salt}] = [NH_4Cl] = 0.4 + 0.2 = 0.2$ M

$\therefore \text{pOH} = \text{p}K_b + \log\left[\frac{\text{Salt}}{\text{Base}}\right]$

$\text{pOH} = 4.74 + \log\left(\frac{0.2}{0.8}\right)$

$= 4.74 - 2\log 2 = 4.74 - 2 \times 0.30 = 4.14$
$\text{pH} = 14 - 4.14 = 9.86$

164 **(b)**
$\text{HCl} = 20 \times 0.1 = 2\ \text{mEq}$
$\text{KOH} = 20 \times 0.1 = 2\ \text{mEq}$
2 mEq HCl combines with 2 mEq of KOH and forms KCl, a salt of S_A/S_B which do not hydrolyses and gives neutral solution with pH = 7

165 **(a)**
$Al_2(SO_4)_3$ is a salt of $\frac{W_B}{S_A}$. $[Al(OH)_3 + H_2SO_4]$. It hydrolyses and gives acidic solution

166 **(d)**
Active mass = Concentration =mol L^{-1}
$$[\text{HI}] = \frac{64}{128 \times 2} = 0.25\ \text{M}$$

167 **(c)**
$K_b = 10^{-5}, \text{p}K_b = 5$
$\therefore [\overset{\ominus}{\text{O}}\text{H}] = C\alpha$
$[\overset{\ominus}{\text{O}}\text{H}] = \sqrt{K_b \times C}$
$$\text{pOH} = \frac{1}{2}(\text{p}K_b - \log C)$$
$$= \frac{1}{2}(5 - \log 0.1) = \frac{1}{2}(5 + 1) = 3$$
$\text{pH} = 14 - \text{pOH} = 14 - 3 = 11$

168 **(d)**
Lewis base is that which can donate a lone pair of e^-s. All except $AlCl_3$ have lone pair of e^-s and can donate. So $AlCl_3$ is not a lewis base

169 **(d)**
Factual statement

170 **(a)**
$\text{pOH} = 13, \text{pH} = 14 - 13 = 1$
Hence, solution is highly acidic

171 **(c)**
$K_{sp}\text{MS} = [M^{2+}][S^{2-}]$
$5 \times 10^{-21} = (0.05)[S^{2-}]$
For precipitation $Q_{sp} = K_{sp}$
$$\therefore [S^{2-}] = \frac{5 \times 10^{-21}}{5 \times 10^{-2}} = 10^{-19}$$
For H_2S:

$H_2S \rightleftharpoons H^{\oplus} + HS^{\ominus} (K_1)$

$HS^{\ominus} \rightleftharpoons H^{\oplus} + S^{2-} (K_2)$
$$K_1 \times K_2 = \frac{[H^{\oplus}]^2 [S^{2-}]}{H_2S}$$
$$10^{-7} \times 10^{-14} = \frac{[H^{\oplus}]^2 [10^{-19}]}{0.1}$$
$[H^{\oplus}]^2 = 10^3, \Rightarrow$ [Taking negative logaritham both sides]
$-2 \log [H^{\oplus}] = 3$
$$\text{pH} = \frac{3}{2} = 1.5$$

172 **(a)**
$\Delta G^{\ominus} = -2.303\, RT \log K$
$= -2.303 \times 2 \times 298 \log 10^{-8}$
$= -2.303 \times 2 \times 298 \times -8$ cal
$= 10980$ cal $= 10.98$ kcal

173 **(c)**
Buffer capacity
$$= \frac{\text{Number of mols/litre of acid or base added}}{\text{change in pH or pOH}}$$
$$= \frac{2}{3.4 - 2.9} = \frac{2}{0.5} = 4$$

174 **(c)**
$$2AB_3(g) \rightleftharpoons A_2(g) + 3B_2(g)$$

	$2AB_3(g)$	$A_2(g)$	$3B_2(g)$
Initial	8	0	0
At eq.	$\frac{8-2x}{1}$	$\frac{x}{1}$	$\frac{3x}{1}$

Since volume $= 1\ dm^3 = 1$ L

At eq. $[A_2] = 2$ mol $= x$

$\therefore [AB_3] = 8 - 2 \times 2 = 4$M

$[A_2] = 2$ M

$[B_2] = 3 \times 2 = 6$ M

$$K = \frac{[B_2]^3[A_2]}{[AB_3]^2} = \frac{6 \times 6 \times 6 \times 2}{4 \times 4} = 27\ \text{mol}^{-2}\ \text{L}^{-2}$$

175 **(d)**
Indicator used for the titration of WA and SB is phenolphthaleim. Since the pH range near the end point is 8 to 10

176 **(d)**
The reactions (a) and (b) are precipitation reactions, they are not reversible. Reaction (d) is an ion- exchange reaction. Hence, it is a reversible

reaction.

$KNO_3(aq) + NaCl(aq) \rightarrow KCl(aq) + NaNO_3(aq)$

177 **(a)**

$ClO_3(OH)$ or $HClO_4$ is the strongest acid

In oxy acids of halogens, the higher the oxidation state of the halogen, the stronger the acid

178 **(b)**

$HIn \rightleftharpoons H^{\oplus} + Ind^{\ominus}$;

$$pH = pK_{Ind} + \log \frac{[Ind^{\ominus}]}{[HIn]}$$

$$pH_1 = pK_{Ind} + \log \frac{20}{80} = pK_{Ind} - 2\log 2$$

$$pH_2 = pK_{Ind} + \log \frac{80}{20} = pK_{Ind} + 2\log 2$$

$$\Delta(pH) = pH_2 - pH_1 = 4\log 2 = 4 \times 0.3 = 1.2$$

180 **(a)**

$$\underset{S}{PbSO_4} \rightleftharpoons \underset{S}{Pb^{2+}} + \underset{S}{SO_4^{2-}}$$

	$Na_2SO_4 \rightarrow$	$2Na^{\oplus}$	$+ SO_4^{2-}$
Initial	0.01	0	0
Final	0	2×0.01	0.01

(Since Na_2SO_4 is salt of S_A/S_B it is completely ionised)

$\therefore SO_4^{2-} = (x + 0.01) = 0.01$ (Since x is very small)

$\therefore K_{sp}$ of $PbSO_4 = [Pb^{2+}][SO_4^{2-}]$

$$1.25 \times 10^{-9} = x \times 0.01$$

$$\therefore x = \frac{1.25 \times 10^{-9}}{0.01} = 1.25 \times 10^{-7} \text{ mol L}^{-1}$$

181 **(a)**

(i)$Ag^+ + NH_3 \rightleftharpoons [Ag(NH_3)]^+$;

$K_1 = 3.5 \times 10^{-3}$

(ii)$[Ag(NH_3)]^+ + NH_3 \rightarrow [Ag(NH_3)_2]^+$;

$K_2 = 1.7 \times 10^{-3}$

On the basis of above reaction,

$$K_1 = \frac{[Ag(NH_3)]^+}{[Ag^+][NH_3]} \quad \ldots(i)$$

$$K_2 = \frac{[Ag(NH_3)_2]^+}{[Ag(NH_3)]^+[NH_3]} \quad \ldots(ii)$$

For the formation of $[Ag(NH_3)_2]^+$

$$Ag^+ + 2NH_3 \rightleftharpoons [Ag(NH_3)_2]^+$$

Formation constant (K)

$$= \frac{[Ag(NH_3)_2]^+}{[Ag^+][NH_3]^2} \quad \ldots(iii)$$

From Eqs. (i) and (ii)

$$K = K_1 \times K_2$$

$$= 3.5 \times 10^{-3} \times 1.7 \times 10^{-3}$$

$$= 5.95 \times 10^{-6} \approx 6.08 \times 10^{-6}$$

182 **(d)**

Salt of S_B/W_A are called acid salts

a. NaH_2PO_4 (Salt of $NaOH + H_3PO_4$) (S_B/W_A)

b. NaH_2PO_4 (Salt of $NaOH + H_3PO_2$) (S_B/W_A)

c. NaH_2PO_3 (Salt of $NaOH + H_3PO_3$) (S_B/W_A)

all are acid salts

183 **(c)**

$$2HX \rightleftharpoons H_2(g) + X_2(g)$$

At equilibrium ? 1.2×10^{-3} M 1.2×10^{-4}M

$$K = \frac{[H_2][X_2]}{[HX]^2}$$

$$10^{-5} = \frac{1.2 \times 10^{-3} \times 1.2 \times 10^{-4}}{[HX]^2}$$

$$[HX] = \sqrt{\frac{1.2 \times 1.2 \times 10^{-7}}{10^{-5}}}$$

$$= 1.2 \times 10^{-1}$$

$$= 12 \times 10^{-2} \text{ M}$$

184 **(d)**

Conjugate base $\overset{\ominus}{O}H$ is O^{2-}

$$\overset{\ominus}{O}H \longrightarrow O^{2-} + H^{\oplus}$$

186 **(b)**

Highest pH will be of the salt of W_A/S_B (pH > 7)

a. NaCl (salt of S_A/S_B pH = 7)

b. Na_2CO_3 (salt of W_A/S_B pH > 7)

c. NH_4Cl (salt of S_A/W_B, pH < 7)

d. $NaHCO_3$ (Salt of W_A/S_B, pH > 7)

but (b) and (d) are both salt of W_A/S_B, but the concentration of salt in (b) is more, so pH is more

$$pH = \frac{1}{2}(pK_w + pK_a + \log C)$$

187 **(a)**

$$PbSO_4(s) \rightleftharpoons Pb^{+2}(aq) + SO_4^{2-}(aq) \; (K_{sp}) \quad \ldots(i)$$

$$HSO_4^{\ominus}(s) \rightleftharpoons H^{\oplus}(aq) + SO_4^{2-}(aq) \quad (K_a) \quad \ldots(ii)$$

Subtracting equation (ii) from (i), then

$$PbSO_4 + H^{\oplus}(aq) \rightleftharpoons Pb^{2+}(aq) + HSO_4^{\ominus}(aq) \quad (K_{eq})$$

$$\therefore K_{eq} = \frac{K_{sp}}{K_a} = \frac{1.8 \times 10^{-8}}{1.0 \times 10^{-2}} = 1.8 \times 10^{-6}$$

188 **(a)**

Salt W_B/S_A hydrlyses and is called cation hydrolysis

189 **(b)**

$$AgCl \rightleftharpoons Ag^{\oplus} + Cl^{\ominus}$$

$$KCl \longrightarrow K^{\oplus} + Cl^{\ominus}$$

Due to common ion effect of $Cl^{\ominus}$, the suppression of ionization of AgCl, takes place and solubility of AgCl decreases

190 **(d)**

mEq of NaOH $= 20 \times \frac{1}{20} = 1$

mEq of HCl $= 10 \times \frac{1}{10} = 1$

So, salt of S_A/S_B (NaCl) will be formed which do not hydrolyse and pH = 7. So at pH = 7, litmus has no effect. Since, blue litmus turns red a acidic solution, and red litmus turns blue, a basic solution

i. phenolphthalein solution turns pink a basic solution of pH > 7

ii. Methyl orange turns red a acidic solution of pH > 7

191 **(d)**

Buffer capacity

$$= \frac{\text{Number of moles per litre of acid or base added}}{\text{Change in pH or pOH}}$$

$$[\text{Acid}] = \frac{0.002 \times 1000}{250} = 0.008\text{ M}$$

Buffer capacity $= \frac{0.008}{0.02} = 0.4$

192 **(a)**

$$\text{pH} = \text{p}K_a + \log\left[\frac{\text{Salt}}{\text{Acid}}\right]$$

$$\text{pH} = \text{p}K_a + \log\left[\frac{\text{In}^{\ominus}}{\text{HIn}}\right]$$

$4.3 = \text{p}K_a + \log 7$

$\text{p}K_a = 4.3 - \log 7$

$\text{p}K_a = 4.3 - 0.845 = 3.455$

$K_a = \text{Antilog}\,(-3.455) = (-3 - 4.55 + 1 - 1)$

$= \bar{4} - 545 = 3.5 \times 10^{-4}$

193 **(d)**

Since the number of moles decreases. So reaction is favoured forward by increasing pressure

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

194 **(b)**

Catalyst does not change the extent of reaction, and hence does not alter the value of K

196 **(c)**

NaOH = 10 × 0.1 = 1 mEq

$Na_2SO_4 = 10 \times 0.1 = 2$ mEq

But pH of solution is due to only strong base, NaOH and will be greater than 7. Salt of S_A/S_B, has no effect on pH, since its pH is 7

197 **(a)**

Salt of S_B/W_A will be basic

a. Sodium borate, salt of S_B/W_A ($NaOH + H_3BO_3$). It gives basic solution

b. NH_4Cl, salt of W_B/S_A, ($NH_4OH + HCl$). It hydrolyses and gives acidic solution

c. $Ca(NO_3)_2$, salt of W_B/S_A [$Ca(OH)_2 + HNO_3$], and gives acidic solution

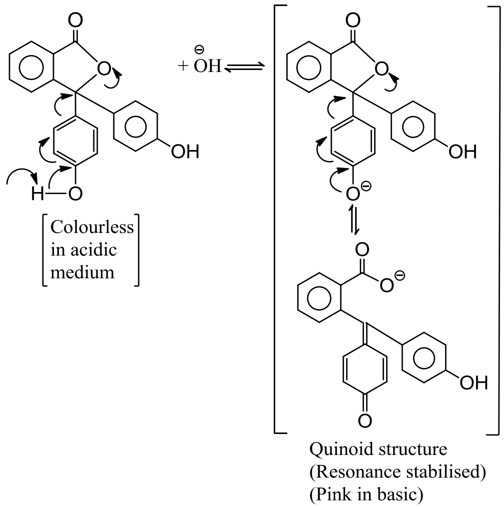
d. Na_2SO_4, salt of S_A/S_B, which do not hydrolyses, gives neutral solution with pH = 7

198 **(c)**

Rate of forward reaction = Rate of backward reaction i.e., when $R_f = R_b$, equilibrium is established

199 **(c)**

Structure of phenolphthalein in acidic and basic medium



200 **(a)**

$K_a \times K_b = 10^{-14}$ for a pair of conjugate acid base

K_b for $X^{\ominus} = 10^{-10}$

K_a for HX $= 10^{-4}$, $\text{p}K_a = 4$

$$\text{pH} = pK_a + \log\frac{[X^{\ominus}]}{[HX]}$$

$= \text{p}K_a = 4$

201 **(a)**

For acidic buffer, $\text{pH} = \text{p}K_a + \log\frac{0.1}{0.1}$

$\text{pH} = \text{p}K_a = -\log(10^{-5}) = 5$

Rule: ABA (In acidic buffer (A), on addition of S_B(B), the concentration of W_A(A) decreases and that of salt increases)

Let x M of NaOH is added

$$\text{pH}_{\text{new}} = 5 + \log\left(\frac{0.1 + x}{0.1 - x}\right)$$

$$6 - 5 = \log\left(\frac{0.1 + x}{0.1 - x}\right)$$

$\left(\frac{0.1+x}{0.1-x}\right) = \text{Antilog}(1) = 10$

Solve for x:

$$x = 0.082\text{ M} = \frac{0.082}{1000} \times 100$$

$= 0.0082\text{ mol }(100\text{ mL})^{-1}$

$= 0.0082 \times 40\text{ g }(100\text{ mL})^{-1}$

$= 0.328$ g

202 **(d)**

The equilibrium constant does not change at all with changes in concentrations, volume, pressure and presence of catalyst. It changes only with changes in temperature of the system

For endothermic reaction, the value of K increases with increase in temperature and vice versa

For exothermic reaction, the value of K decreases with increase in temperature and vice versa

203 **(b)**

NaX: Salt of weak acid, strong base

$$\Rightarrow \alpha = \sqrt{\frac{K_h}{C}} = \sqrt{\frac{K_w}{K_a . C}} = \sqrt{\frac{10^{-14}}{10^{-5} \times 0.1}} = 10^{-4}$$

$\Rightarrow$ % hydrolysis $= 0.01\%$

(Check that approximation is valid)

204 **(a)**

$N_2 + O_2 \rightleftharpoons 2NO$ ... (i)

$NO \rightleftharpoons \frac{1}{2}N_2 + \frac{1}{2}O_2$ ... (ii)

Equation (ii) is obtained by reversing equation (i) and dividing by 2

$$\therefore K_2 = \frac{1}{(K_1)^{1/2}}$$

$$\Rightarrow (K_2)^2 = \frac{1}{K_1}$$

$$\Rightarrow K_1 = \frac{1}{(K_2)^2} = \left(\frac{1}{K_2}\right)^2$$

205 **(c)**

a. It is a mixture of S_A + salt of S_A/S_B. So pH is due to S_A and is less than 7

b. mEq of $H_2SO_4 = 100 \times 0.2 \times 2 = 40$

mEq of NaOH $= 100 \times 0.3 = 30$

So 30 mEq of NaOH will react with 30 mEq of H_2SO_4

So 10 mEq of H_2SO_4 (strong acid will be left)

So pH will be less than 7

c. mEq of $CH_3COOH = 100 \times 0.1 = 10$

mEq of KOH $= 100 \times 0.1 = 10$

So 10 mEq of W_A (CH_3COOH) will react with 10 mEq of KOH (S_B) to give 10 mEq of salt (CH_3COONa). It is a salt of W_A/W_B

So its pH will be greater than 7

$$\text{pH} = \frac{1}{2}(\text{p}K_w + \text{p}K_a + \log C)$$

d. mEq of $HNO_3 = 2.5 \times 0.1 = 2.5$

mEq of $NH_3 = 2.5 \times 0.1 = 2.5$

So 2.5 mEq of HNO_3 will react with 2.5 mEq of NH_3 to give 2.5 mEq of NH_4NO_3, which is a salt of W_B/W_A, and its pH is always less than 7

$$\text{pH} = \frac{1}{2}(\text{p}K_w - \text{p}K_b - \log C)$$

206 **(a)**

Acidic buffer is a mixture of a weak acid and its salt with a strong base in solution

$$CH_3COOH \rightleftharpoons CH_3COO^{\ominus} + H^{\oplus}$$

$$CH_3COONa \longrightarrow CH_3COO^{\ominus} + Na^{\oplus}$$

Adding acid: When a small amount of acid is added, $H^{\oplus}$ ions combine with acetate ions to form the weak electrolyte acetic acid than does not dissociate, so the pH does not change

Adding base: When a small amount of base is added, $\overset{\ominus}{OH}$ ions combine with $H^{\oplus}$ ions to form the weak electrolyte water than does not dissociate, so the pH does not change

207 **(d)**

10^{-8}M HCl

At such a low concentration the contribution of $[H^{\oplus}]$ from water cannot be neglected, which is 10^{-7}

In such cases, the pH of the acid can be calculated to be slightly less than 7

208 **(d)**

$PCl_5 \rightleftharpoons PCl_3 + Cl_2$

If the concentration of PCl_3 is doubled, it only predicts, that reaction will proceed backward. (Le-Chatlier's principle). So the concentration of Cl_2 is unpredictable

209 **(c)**

The two K_{sp} values do not differ very much. So it is a case of simultaneous equilibria, where the concentration of any species can not be neglected

$$\frac{\cancel{[Sr^{2+}]}\,[F^{\ominus}]^2}{\cancel{[Sr^{2+}]}\,[CO_3^{2-}]} = \frac{K_{sp}\,SrF_2}{K_{sp}\,SrCO_3} = \frac{7.9 \times 10^{-10}}{7.0 \times 10^{-10}} = 1.128$$

$$\therefore [F^{\ominus}]^2 = 1.28 \times [CO_3^{2-}] = 1.128 \times 1.2 \times 10^{-3}$$

$$= 13.5 \times 10^{-14}$$

$$\therefore [F^{\ominus}] = (13.5 \times 10^{-4})^{1/2}$$

$$= 3.674 \times 10^{-2} \approx 3.7 \times 10^{-2} \text{ M.}$$

210 **(b)**

$K_{sp} = 1.7 \times 10^{-10}$

After mixing equal volumes, we get

$[Ca^{2+}] = \frac{10^{-2}}{2} = 0.005 = 5 \times 10^{-3}$

$[F^{\ominus}] = \frac{10^{-3}}{2} = 0.0005 = 5 \times 10^{-4}$

For CaF_2,

Ionic product $= [Ca^{2+}] \times [F^{\ominus}]^2$

$= [5 \times 10^{-3}] \times [5 \times 10^{-4}]^2$

$= 125 \times 10^{-11}$

$= 1.25 \times 10^{-9}$

Since ionic product is greater than solubility product, precipitation occurs

211 **(c)**

$N_2 + 3H_2 \rightleftharpoons 2NH_3 + \text{Heat}$

$\Delta n = 2 - (1 + 3) = -2$

$\therefore K_p = K_c(RT)^{-2}$

212 **(a)**

As the temperature is increased, solubility of solid in liquid increases and hence equilibrium shifts to the right and hence the amount of solid decreases

Solid + aq $\rightarrow$ Solution

213 **(a)**

The given reaction will be exothermic in nature due to the formation of three $X - Y$ bonds from the gaseous atoms. The reaction is also accompanied with the decrease in gaseous species. Hence, the reaction will be affected by both temperature and pressure. The use of catalyst does not affect the equilibrium concentration of the species in the chemical reaction

214 **(c)**

The characteristics of the given solutions are:

NaCl Neutral solution (Salt of S_A/S_B)

NH_4Cl Slightly acidic due to the reaction (Salt of W_B/S_A)

$NH_4^{\oplus} + H_2O \rightleftharpoons NH_4OH + H^{\oplus}$

NaCN Slightly alkaline due to the reaction (Salt of S_B/W_A)

$CN^{\ominus} + H_2O \rightleftharpoons HCN + OH$

HCl highly acidic

The pH of the solution will follow the order highly acidic < slightly acidic < neutral < slightly alkaline.

i.e., $HCl < NH_4Cl < NaCl < NaCN$

215 **(a,b,c,d)**

All factual statements

217 **(c,d,e)**

At constant volume, There is no effect of addition of inert gas to a reaction in equilibrium. At constant pressure, for the reactions for which $\Delta n = 0$, there is no effect of addition of inert gas to a reaction in equilibrium. At constant pressure, for the reactions for which $\Delta n \neq 0$, the equilibrium shifts in the direction of more number of moles. Addition of the reactant favours forward reaction. Increasing the volume means decreasing the pressure, which shifts the reaction in the direction of more number of gaseous moles

221 **(b,c)**

$K_1K_2 = \frac{[H^{\oplus}]^2[S^{2-}]}{[H_2S]} = 10^{-21}$

Note: *Saturated* H_2S *means* 0.01 M H_2S

i. $\frac{(0.2)^2/[S^{2-}]}{0.1} = 10^{-21}$

$\therefore [S^{2-}] = \frac{10^{-22}}{0.04} = 2.5 \times 10^{-21}$

$K_{sp} = [Fe^{2+}][S^{2-}] = 3.7 \times 10^{-19}$

Since $(0.01)(2.5 \times 10^{-21}) < 3.7 \times 10^{-19}$

FeS will not precipitate

ii. $\frac{(0.001)^2/[S^{2-}]}{0.1} = 10^{-21}, [S^{-2}] = 10^{-16}$

Since $(0.1)(10^{-16}) < 3.7 \times 10^{-19}$

FeS will precipitate

225 **(b,d)**

a. Wrong statement

b. Correct: Indicator are weak acid or base and are added is small amount. So they do not affect the pH of the solution

c. Wrong: They occur even in the absence of indicators

d. Correct: Factual statement

228 **(a,c)**

K_w changes with temperature and salts of strong acid and strong base do not undergo hydrolysis

230 **(a,d)**

Reaction quotient$= \frac{p^2_{NH_3}}{p_{N_2} \cdot p^3_{H_2}} = \frac{(0.05 \text{ atm})^2}{(0.05 \text{ atm})(3.0 \text{ atm})^3}$

$= 1.85 \times 10^{-3} \text{atm}^{-2}$

The value of $K_p$is $4.28 \times 10^{-5} \text{atm}^{-2}$. The numerical value of Q_p is more than that of K_p. The reaction goes towards the left the thus, ammonia decomposes into H_2 and N_2

232 **(b,c,d)**

$$K_1 = \frac{K_f}{K_b} = \frac{2\times10^{-2}}{4\times10^{-3}} = 5 \text{ at } 300\text{ K}$$

$$K_2 = \frac{K_f}{K_b} = \frac{4\times10^{-2}}{16\times10^{-4}} = 25 \text{ at } 400\text{ K}$$

$$\therefore 2.303\log\frac{25}{5} = \frac{\Delta H}{2}\times\left[\frac{400-300}{400\times300}\right]$$

Or $\Delta H = 3.86$ kcal

234 **(a,b)**

$\mathrm{p}K_a = -\log(3\times10^{-5}) = -0.48+5 = 4.52$

$\mathrm{H_{Ind}} \rightleftharpoons \mathrm{Ind}^{\ominus} + \mathrm{H}^{\oplus}$

(Red) (Blue)

(i) 75% 25%

(ii) 25% 75%

(i) $\mathrm{pH} = 4.52 + \log\left(\frac{25}{75}\right)$

$= 4.52 + \log\frac{1}{3} = 4.52 - 0.48 = 4.04$

(ii) $\mathrm{pH} = 4.52 + \log\left(\frac{75}{25}\right)$

$= 4.52 + 0.48 = 5.0$

235 **(a,b)**

A buffer can be obtained with the following combinations

(i)A weak base + its salt with a strong acid

(ii)A weak acid + its salt with a strong base

241 **(a,c)**

Le-Chatelier's principle is not quantitative if both stress would cause the same direction of shift, the shift is determinable. If the two stresses would cause shifts in opposite directions, no deduction is possible

244 **(a,c,d)**

$\mathrm{N_2O_4} \rightleftharpoons 2\mathrm{NO_2}$

a 0 initial

$a(1-\alpha)$ $2a\alpha$at equilibrium

Vapour density $= \frac{46}{1+\alpha}: 30.67$

So, $(1+\alpha) = \frac{46}{30.67} = 1.5$ or $\alpha = 50\%$

Total pressure $= \frac{1.5\times1.5\times0.082\times300}{8.2} = 6.75$ atm

So, $K_p = \frac{4\alpha^2}{1-\alpha^2} = 9$ atm

Density of mixture $= \frac{138}{8.2}$ g/L $= 16.83$ g/L

245 **(a,b,d)**

$$Q = \frac{[S_2]^4}{[S_8]} = \frac{(0.2)^4}{(2)} = 8\times10^{-4};\ K_c = 6.3\times10^{-6}$$

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

$= 6.3\times10^{-6}\times(0.0821\times900)^3$

$= 2.55$

Thus, reaction proceed in backward direction since $Q > K_c$

246 **(c,d)**

$2\mathrm{NaNO_3(g)} \rightleftharpoons 2\mathrm{NaNO_2(g)} + \mathrm{O_2(g)}$

$\Delta H =$ positive, endothermic

Addition of solids does not affect the equilibrium. Endothermic reaction is favoured by increase in temperature

Increased pressure shifts the equilibrium in the direction of less gaseous moles

247 **(b)**

$\mathrm{Hg_2CrO_4} \rightleftharpoons \mathrm{Hg_2}^{2+} + \mathrm{CrO_4}^{2-}$

$[\mathrm{Hg_2}^{2+}] = 4\times10^{-4}\mathrm{M}, [\mathrm{CrO_4}^{2-}] = 2\times10^{-5}$

$K_{\mathrm{sp}} = (4\times10^{-4})(2\times10^{-5}) = 8\times10^{-9}$

248 **(b,c,d)**

Salt of S_A and W_B: $h = \sqrt{\frac{K_h}{C}} = \sqrt{\frac{K_w}{K_b\cdot C}}$

$\Rightarrow h$ increases as 'C' decreases [on dilution]

As T increases, K_h increases $\Rightarrow h$ increases

As T decreases, K_h decreases $\Rightarrow h$ decreases

As strength of base decreases (i.e., $\mathrm{K_b}$ decreases) $\Rightarrow h$ increases

Note:*Both K_w and K_b increase with increase in temperature but K_w will increase sharply but K_w will increase sharply as compared to K_w So K_b increases with increase in temperature*

251 **(b,c)**

Self-explanatory

254 **(a,b)**

$\mathrm{HIn} \rightleftharpoons \mathrm{Ind}^{\ominus} + \mathrm{H}^{\oplus} (pK_a = 5)$

Red Blue

a. when $\mathrm{pH} < \mathrm{p}K_a$ $(4.52 < 5)$, colour of acid form, i.e, red predominates

b. when $\mathrm{pH} > \mathrm{p}K_a (5.47 > 5)$, colour of basic form, i.e, blue predominates

c. 75% red $\Rightarrow \left[\frac{\mathrm{In}^{\ominus}}{\mathrm{HIn}}\right] = \frac{0.75}{0.25}$

$\Rightarrow \mathrm{pH} = 5 + \log 3 = 5 + 0.48 = 5.48$ (Hence (c) is wrong)

(d) is also wrong statement

263 **(a,b,c,d)**

$\mathrm{A(s)} \rightleftharpoons 2\mathrm{B(g)} + \mathrm{C(g)}$

$$2\alpha + 2\alpha' \quad \alpha$$

$$A'(s) \rightleftharpoons 2B + D$$

$$2\alpha' + 2\alpha \quad \alpha'$$

$$K_{p_1} = (2\alpha + 2\alpha')^2 \times \alpha \times \left[\frac{P}{(3\alpha + 2\alpha')}\right]^3$$

$$K_{p_2} = (2\alpha + 2\alpha')^2 \times \alpha' \times \left[\frac{P}{(3\alpha' + 2\alpha)}\right]^3$$

$$\frac{K_{p_1}}{K_{p_2}} = \frac{[3\alpha' + 2\alpha]^3}{[3\alpha + 2\alpha]^3} \times \frac{\alpha}{\alpha_1}$$

Also, $K_{p_1} = (P'_B)^2 \times P'_c$

$K_{p_2} = (P'_B)^2 \times P'_p$

Or $\frac{P'_c}{P'_D} = \frac{K_{p_1}}{K_{p_2}} = \frac{8\times10^{-2}}{2\times10^{-2}} = 4$

Also, $P'_B = 2 \times (P'_c + P'_D)$

$K_{p_1} > K_{p_2} \quad \therefore \alpha > \alpha_1$

265 **(b,d)**

Since $\Delta H < 0$ i.e., $\Delta H < -$ve,
Reaction is exothermic, so lowering of temperature will shift equilibrium towards right. Statement (d) is correct and also the concentration of reactants decreases and products increases. So statement (b) is also correct

268 **(d)**

$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$
At constant volume, there is no effect of addition of inert gas to a reaction in equilibrium
At constant pressure, for the reactions for which $\Delta n = 0$, there is no effect of addition of inert gas to a reaction in equilibrium. The presence of a catalyst just helps to achieve the equilibrium at a different pace. It does not affect the amount of a reactant or a product at equilibrium
Only if the reactant concentration is increased, the equilibrium shifts forward and the product concentration is increased

269 **(a,b,d)**

In aqueous solution, a salt of weak acid and a weak base acts as a buffer solution. The pH of a buffer solution do not change on dilution. Thus, pH of 0.01 M CH_3COONH_4 will not change on dilution. HCO_3^-fromNaHCO_3 and $H_2PO_4^-$ from NaH_2PO_4 are amphiprotic anions. The pH of solution containing amphiprotic anions do not change on dilution

272 **(d)**

For precipitation, $[Ag^{\oplus}]$ ion should be minimum in the solution

$$\text{For AgCl:} \quad [Ag^{\oplus}]_{min} = \frac{K_{sp}\,AgCl}{[Cl^{\ominus}]} = \frac{1.5\times10^{-10}}{1.5\times10^{-1}}$$
$$= 10^{-9}M$$

$$\text{For AgBr:} \quad [Ag^{\oplus}]_{min} = \frac{K_{sp}\,AgBr}{[Br^{\ominus}]} = \frac{5.0\times10^{-13}}{5.0\times10^{-4}}$$
$$= 10^{-9}M$$

For Ag_2CrO_4: $[Ag^{\oplus}]_{min}$

$$= \left(\frac{K_{sp}Ag_2CrO_4}{[CrO_4{}^2]}\right)^{\frac{1}{2}} = \left(\frac{1.9\times10^{-12}}{1.9\times10^{-2}}\right) = 10^{-5}\text{ M}$$

Therefore, $[Ag^{\oplus}]$ min in solution is in AgCl and AgBr, so both will be precipitated

280 **(a,b)**

Either buffer to salt of W_A/W_B solutions pH values does not change on dilution
Since in buffer, on dilution both the concentration of W_A or W_B and their conjugate ions change, but their ratio remains same
Hydrolysis of salts of W_A/W_B are independent on the concentration, so their pH values also does not change on dilution

282 **(a,b)**

Increasing the concentration of reactants favours the product formation

285 **(a,b,c,d)**

Calculate of molecular weight of BOH:
Eq of base = Eq of H_2SO_4 used

$$\frac{0.496\text{ g}}{Mw\text{ of base}} \times 1 = 40 \times 10^{-3} \times \frac{1}{2} \times 2(n\text{ factor})$$

$\therefore Mw$ of BOH $= 12.4\text{ g mol}^{-1}$
Now: $\Delta_f T = iK_f m$

$$0.165 = i \times 1.86 \times \frac{1.5}{12.4} \times \frac{1000}{150}$$

$= i \times 1.86 \times 0.8$ (So $m = 0.8$)

$$\therefore i = \frac{0.165 \times 12.4}{1.86} = 1.1$$

For weak base: $1 + \alpha = 1.1, \Rightarrow \alpha = 0.1 = 10\%$ (Answer d)
Thus, $[\overset{\ominus}{O}H] = C\alpha = 0.8 \times 0.1 = 8 \times 10^{-2}$,
$\therefore$ pOH $= 1.1$, pH $= 12.9$ (Answer a)
So, $K_b = C\alpha^2 = 0.8 \times (0.1)^2 = 8 \times 10^{-3}$, (Answer b)
Also; $\pi = iMRT$

$= 1.1 \times 0.8 \times 0.0821 \times 300$
$= 21.67$ atm (Answer c)

287 **(a,b,c)**
As concentration of reactant is increased at equilibrium, reaction will go in the forward direction. Because of endothermic nature it is also favoured by increase in temperature

290 **(a,c)**
For any polyprotic acid: $K_{a_1} > K_{a_2} >$... and so on

292 **(a)**

i. $Ag_2SO_4 \rightleftharpoons \underset{2x}{2Ag^{\oplus}} + \underset{x}{SO_4^{2-}}$

ii. $BaSO_4 \rightleftharpoons \underset{y}{Ba^{2+}} + \underset{y}{SO_4^{2-}}$

iii. $Ba_3(PO_4)_2 \rightleftharpoons \underset{3z}{3Ba^{2+}} + \underset{2z}{2PO_4^{3-}}$

$\therefore [Ag^{\oplus}] = 2x,\ [SO_4^{2-}] = x + y,\ [Ba^{2+}] = x + 3z;$
$[PO_4^{3-}] = 2z$

Direct method: By electroneutrality
[Total positive charge = Total negative charge
Total charge = Charge on the ion × Concentration

iv. $1 \times [Ag^{\oplus}] + 2[Ba^{2+}] = 2[SO_4^{2-}] + 3[PO_4^{3-}]$

Alternatively: Substituting the concentration of each ion in (iv)

$2x + 2(x + 3z) = 2(x + y) + 3(2z)$

Dividing by 2: $x + (x + 3z) = (x + y) + \frac{3}{2}(2z)$

$$\frac{[Ag^{\oplus}]}{2} + [Ba^{2+}] = [SO_4^{2-}] + \frac{3}{2}[PO_4^{3-}]$$

or

$[Ag^{\oplus}] + 2[Ba^{2+}] = 2[SO_4^{2-}] + 3[PO_4^{3-}]$

Hence answer is (a)

298 **(a,c,d)**
K_p depends upon temperature only

299 **(a,b,d)**
For acidic buffer, buffer capacity is maximum at $pH = pK_a$ and for basic buffer, it is maximum at $pH = pK_w - pK_b$. Buffer is always effective withn a pH range of 1 with respect to the pH at maximum buffer capacity
$H_3PO_4 + H_2PO_4^{\ominus}$ is a buffer solution

303 **(c)**
a. For the titration of W_A and W_B, there is no sharp change in the pH value near the end point (pH varies between 6.0 and 8.0)
So indicator V can not be used. But indicator X can be used
$CH_3COOH + NH_4OH \Rightarrow pH = 7$

b. $\left.\begin{array}{l} 0.1\ M\ NaOH \Rightarrow pH = 13 \\ 0.001\ M\ NaOH \Rightarrow pH = 11 \end{array}\right]$
Y cannot be used. Choose an indicator which has different colour for pH = 13 and 11
c. X can be used since it will give different colour in both the solutions. NH_4Cl (Salt of W_B/S_A $pH < 7$) and CH_3COONa (salt of W_A/W_B $pH < 7$)
d. Y will be suitable indicator not W
$CH_3COOH + \text{Base} \Rightarrow pH > 7$

310 **(a,b)**
Factual statements

312 **(a,b)**
$\Delta G^{\ominus} = -nRT$ In K and 2.303 log K
$$= \frac{-\Delta H^{\ominus}}{RT} + \frac{\Delta S^{\ominus}}{R}$$

315 **(b,c)**
Acidic buffer: $pH = pK_a + \log\frac{[\text{Salt}]}{[\text{Acid}]}$ If more salt is added, pH increases
Basic buffer: $pOH = pK_b + \log\frac{[\text{Salt}]}{[\text{Base}]}$ If more salt is added, $pOH = pK_b + \log\frac{[\text{Salt}]}{[\text{Base}]}$ If more salt is added, pOH increases or pH decreases

317 **(b,d)**
$MgCl_2$ + NaF [After dilution]
7.5×10^{-4}M 1.25×10^{-2} M
I.P. of $MgF_2 = [Mg^{2+}][F^{\ominus}]^2$
$= (7.5 \times 10^{-4})(1.25 \times 10^{-2})^2 > K_{sp(MgF_2)}$
$\Rightarrow MgF_2$ will get precipitated and $Cl^{\ominus}$ ions will remain in solution

320 **(a,c)**

$$CH_3NH_2 + HCl \longrightarrow CH_3\overset{\oplus}{N}H_3 + Cl^{\ominus}$$

Initial moles 0.1 0.08
Final $(0.1 - 0.08)$ $(0.008 - 0.008)$ 0.008
$= 0.02$ $= 0$

Since W_B is left, so it forms basic buffer solution

$$[\overset{\ominus}{O}H] = K_b\frac{[\text{Base}]}{[\text{Salt}]} = 5 \times 10^{-4} \times \frac{0.02}{0.08}$$
$$= 1.25 \times 10^{-4}$$

$$[H^{\oplus}]\ \frac{K_w}{[\overset{\ominus}{O}H]} = \frac{10^{-14}}{1.25 \times 10^{-4}} = 8 \times 10^{-11}M$$

$pH = -\log(8 \times 10^{-11})$
$= -\log 2^4 + 11$
$= -0.3 \times 4 + 11 = 9.8$
$pOH = 14 - 9.8 = 4.2$

326 **(b,d)**

The van't Hoff equation is $K = Ae^{-\Delta H/RT}$

or $\frac{d\ln k}{\partial T} = \frac{\Delta H}{RT^2}$

328 **(a,b)**

As the reaction is exothermic, low temperature will favour dissociation. Moreover, as $n_p > n_r$, low pressure favours dissociation

330 **(b,d)**

a. **Wrong**: Indicator should have a small transition range

b. **Correct**: pH at equivalence point = pH_{Ind}

c. **Wrong**: pH at equivalence point and at the end point may be different

d. **Correct**: Factual statement

331 **(a,b,c)**

a. $M = \frac{W_2\times 1000}{Mw_2\times V_{sol}(in\ mL)} = \frac{2\times 1000}{40\times 500} = 0.1\ \text{M}$

$\therefore$ [NaOH]= $[\overset{\ominus}{\text{OH}}] = 0.1 = 10^{-1}$ M

pOH = 1, pH = 3

b. 0.05 M $Ca(OH)_2 = 2\times 0.05$ N $Ca(OH)_2$

$\therefore [\overset{\ominus}{\text{OH}}] = 2\times 0.05 = 0.1 = 10^{-1}$M

pOH = 1, pH = 13

c. 100 mL of 0.1 N $Ca(OH)_2$,

$\therefore [\overset{\ominus}{\text{OH}}] = 0.1\ \text{N} = 10^{-1}$ M

pOH = 1 pH = 13

d. $\text{M} = \frac{4\times 1000}{40\times 500} = \frac{1}{5} = 0.2\ M$

$[\overset{\ominus}{\text{OH}}] = 0.2$ M

$\text{pOH} = -\log[0.2] = -\log 2 + \log 10$

$= -0.3010 + 1$

$= -0.699$

pH = 14 − 0.699 = 13.301

So the answer (a), (b), and (c) are correct

332 **(a,b,d)**

NaCl + NaI

0.05 M 0.05 M

When $AgNO_3$ is added, find the minimum concentration of $Ag^{\oplus}$ required to start precipitation

$$[Ag^{\oplus}]_{AgCl} = \frac{K_{sp\,(NaCl)}}{[Cl^{\ominus}]} = \frac{10^{-10}}{0.05} = 2\times 10^{-9}\ \text{M}$$

$$[Ag^{\oplus}]_{AgI} = \frac{K_{sp\,(AgI)}}{[I^{\ominus}]} = \frac{4\times 10^{-16}}{0.05} = 8\times 10^{-15}\ \text{M}$$

Since, there is a very high difference between the minimum concentration of $Ag^{\oplus}$, precipitation is selective and AgI will precipitate first

336 **(a,b,c,d)**

Applying Le Chatelier's principle, when the temperature is increased, the equilibrium shifts in the direction of the endothermic reaction. When the pressure is increased, the equilibrium shifts in the direction of less number of moles. The removal of a reactant and addition of a product shift the equilibrium in the backward direction

337 **(a,b,c,d)**

$\Delta G = \Delta G^{\ominus} + 2.303\,RT\log Q$

$\Delta G = 2\times G^{\oplus}_{NO_2} - G^{\ominus}{}_{N_2O_4} = 2\times 50 - 100 = 0$

$\therefore \Delta G = 0 + 2.303\times 8.314\times 10^{-3}\times 298\log\frac{22}{5}$

$= 0 - 0.55$ kJ

$\therefore \Delta G = -0.55$ kJ, i.e., reaction proceed in forward direction

Also $\Delta G^{\oplus} = 0 = 2.303\,RT\log K \quad \therefore K = 1$

Now, $N_2O_4 = 2NO_2$

$5 \qquad 2$

$5 - x \qquad 2 + 2x$

$\therefore K_p = \frac{(P_{NO_2})}{(P_{N_2O_4})} = 1 = \frac{(2+2x)^2}{5-x}$ or $x = 0.106$

340 **(a,b,c)**

Since concentration are identical

If V_1 is the volume of CH_3COOH and V_2 is the volume of NaOH

a. $\left.\begin{array}{cc} CH_3COOH\ + & NaOH \\ V_1 & V_2 \end{array}\right]$ Buffer is formed if $V_1 > V_2$

$M_1 \quad \approx \quad M_2$

mmol of $CH_3COOH(M_1V_1) >$ mmol of $NaOH(M_2V_2)$. So W_A is left and buffer is formed

b. $\left.\begin{array}{cc} CH_3COOK + HNO_3 \rightarrow CH_3COOH + KNO_3 \\ V_1 \qquad\qquad V_2 \end{array}\right]$

$M_1 \quad \approx \quad M_2$

Buffer is formed $V_1 > V_2$

mmol of salt $(CH_3COOK) > mmol$ of HNO_3. Some salt is hydrolysed to give CH_3COOH and some salt CH_3COOK is left to give buffer solution. KNO_3 is completely ionized

c. $\left.\begin{array}{cc} CH_3COOH + & CH_3COOK \\ V_1 & V_2 \end{array}\right]$

Forms always a buffer. Mixture of W_A and salt of W_A/S_B

d. $HNO_3 + CH_3COOH$] It is a mixture of S_A and W_A

345 **(a,b,c)**

Salt of W_B/S_A have pH > 7

Note: *Salt of* $\frac{W_A}{W_B}$ *have* $pH < 7$ *if acidic part is stronger i.e., if* $pK_b > pK_a$

a. $NH_4F \equiv NH_3 + HF$ $(K_a > K_b$ or $pK_b > pK_a)$
W_B W_A (pH < 7)

b. $Cr(NO_3)_3 \equiv Cr(OH)_3 + HNO_3$ [pH < 7]
W_B S_A

c. $[(CH_3)_3NH]Cl \equiv (CH_3)_3\overset{\oplus}{N}H\,\overset{\ominus}{O}H + HCl$ (pH > 7)
W_B S_A

d. $CaI_2 \equiv Ca(OH)_2 + HI$(pH $= 7$)
S_B S_A

346 **(a,c)**

A buffer solution is obtained by mixing a weak acid/base with salt of its conjugate base/acid

351 **(b,d)**

a. Statement (a) is correct

K_a values decreases successively, since it is difficult to remove $H^{\oplus}$ ion from an anion than a neutral compound. Similarly, it is difficult to remove $H^{\oplus}$ ion from dianion than and anion

Hence $K_{a_1} > K_{a_2} > K_{a_3}$

b. Statement (b) is incorrect

$$H_3PO_4 \xrightleftharpoons{Ka_1} H^{\oplus} + H_2PO_4^{\ominus}$$

$$H_3PO_4^{\ominus} \xrightleftharpoons{Ka_2} H^{\oplus} + HPO_4^{2-}$$

$$pH(H_2PO_4^{\ominus}) = \frac{pKa_1 + pKa_2}{2}$$

This is valid only when H_3PO_4 during titration is completely converted to $H_2PO_4^{\ominus}$

$$HPO_4^{2-} \xrightleftharpoons{Ka_3} H^{\oplus} + PO_4^{3-}$$

$$pH(HPO_4^{2-}) = \frac{pK_{a_2} + pK_{a_3}}{2}$$

This is again valid when starting with $H_2PO_4^{2-}$ and is completely converted to HPO_4^{2-}

c. Statement (c) is correct

From the K_a values, it is evident that both H_3PO_4 and $H_3PO_4^{\ominus}$ are more acidic than HPO_4^{2-}

d. Statement (d) is incorrect

Both $H_2PO_4^{\ominus}$ and HPO_4^{2-} are amphiprotic anion in the solution

$$H_3PO_4 \xleftarrow{+H^{\oplus}} H_2PO_4^{\ominus} \xrightarrow{-H^{\oplus}} HPO_4^{2-} + H^{\oplus}$$

$$H_2PO_4^{\ominus} \xleftarrow{+H^{\oplus}} HPO_4^{2-} \xrightarrow{-H^{\oplus}} PO_4^{3-} + H^{\oplus}$$

355 **(a,b,c)**

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

357 **(b,d)**

a. $\Delta n = 1 + 1 - 1 = 1$

$b.\ \Delta n = 2 - (1 + 1) = 0$

c. $\Delta n = 1 - 0 = 1$

d. $\Delta n = 1 + 1 - (1 + 1) = 0$

Δn is zero in (b) and (d), so (b) and (d) are not effected by pressure

359 **(a,b)**

a. Correct: At the point, $[H^{\oplus}]$ becomes small and to change it, small amount of $[\overset{\ominus}{O}H]$ is required. When $[H^{\oplus}]$ change from 10^{-6}M to 10^{-7}M, pH change is one, but the volume of NaOH required for this change is very small. So, the curve changes sharply

b. Correct: Quinoid structure is obtained

(c) and (d) are wrong statements

361 **(a,b,d)**

$K_p = K_c(RT)^{\Delta n}$, when $\Delta n \neq 0, K_p \neq K_c$

366 **(a,b,c,d)**

$$A_2 \rightleftharpoons 2C + D$$

Initial	1	0	0
At equilibrium	$1 - \alpha$	2α	α

$$K_p = (2\alpha)^2\alpha \times \left[\frac{P}{\Delta n}\right]^2 = \frac{4\alpha^3 P^2}{(1 + 2\alpha)^2}$$

Use $2.303 \log \frac{K_2}{K_1} = \frac{\Delta H}{R}\left[\frac{T_2 - T_1}{T_1T_2}\right]$ for effect temperature on K

371 **(a,c)**

a. $CH_3COONa + CH_3COOH$ (Acidic buffer, mixture of salt of W_A/S_B and W_A)

b. It is not buffer. [Mixture of salt of W_A/S_B and S_A]

c. $NH_3 + NH_4Cl$ (Basic buffer, mixture of W_B and salt of W_B/S_A)

d. $NH_3 + NH_4OH$ (not buffer, mixture of W_B)

373 **(a,b,d)**

Factual statements

376 **(b,c,d)**

(a) is wrong

For reaction of S_A with W_B, basic buffer is formed

β is maximum. When pOH $= pK_b$

At 50% neutralization (24 mL of 0.1 N HCl)

Slope of the given graph will be least and the buffer will have maximum buffer capacity

377 **(d)**

At constant volume, there is no effect of addition of inert gas to a reaction in equilibrium. At constant pressure, for the reactions for which $\Delta n = 0$. There is no effect of addition of inert gas to a reaction in equilibrium. At constant pressure, for the reactions for which $\Delta n \neq 0$, the equilibrium shifts in the direction of more number of moles

386 **(a,b,c,d)**
After dilution $[H^+] = 10^{-2}$
$pH = 2$
Let V L solution of pH=2 is added in original solution so that pH remains fixed
$$\therefore [H^+] = \frac{10^{-2}x + V \times 10^{-2}}{10 + V} = 10^{-2}$$
This result is independent of volume taken

387 **(a,c)**
Addition of H_2O will not change pH only for buffer solution. (Buffer is formed if W_A or W_B is left after neutralization)
a. Acid buffer: $CH_3COOH = 100 \times 0.2 = 20$ mmol
$NaOH = 100 \times 0.1 = 10$ mmol
10 mmoles of CH_3COOH will react with 10 mmol of NaOH to form 10 mmol of CH_3COONa and 10 mmol of CH_3COOH is left
b. mmol of $CH_3COOH = 100 \times 0.2 = 20$
mmol of $NaOH = 100 \times 0.2 = 20$
(Salt of W_A/W_B is formed)
c. mmol of $CH_3COOH = 200 \times 0.2 = 40$
mmol of $NaOH = 100 \times 0.1 = 10$
mmol of CH_3COOH left $= 40 - 10 = 30$
mmol of CH_3COONa formed $= 10$
(Buffer is Formed)
d. mmol of $CH_3COOH = 100 \times 0.2 = 20$
mmol of $NaOH = 200 \times 0.2 = 40$
mmol of NaOH left $= 40 - 20 = 20$
S_B is left

388 **(b,c)**
a. The pH of 1.0×10^{-8} M solution of HCl is not 8, it is less than 7
b. $H_2PO_4^{\ominus} \rightleftharpoons HPO_4^{2-} + H^{\oplus}$
c. Autoprotolysis constant of water or ionic product of water increases with increase in temperature
d. When a solution of a weak monoprotic acid is treated against a strong base, at half-neutralisation point $pH = pK_a$

389 **(c)**
Explanation is correct reason for statement

390 **(c)**
Catalyst increases forward as well as backward reaction

391 **(c)**
Explanation is correct reason for statement.

392 **(b)**
Both (A) and (R) are correct but (R) is not the correct explanation of (A)

Correct R: Na_2CO_3 reacts with HCl upto the stage of $NaHCO_3$ in the presence of phenolphthalein

$Na_2CO_3 + HCl \rightarrow NaHCO_3 + NaCl$

393 **(b)**
(A) is correct because aqueous solution of salt of W_A and W_B acts as buffer

(R) is correct. Buffer resist the change in pH on addition of small amount of S_A or S_B

But it is not the correct explanant of (A)

394 **(c)**
$$2.303 \log \frac{K_{c_2}}{K_{c_1}} = \frac{\Delta H}{R} \frac{[T_2 - T_1]}{T_1 T_2}; \text{ if } \Delta H = -\text{ve}, K_{c_2} < K_{c_1}$$
$$\text{if } \Delta H = +\text{ve}, K_{c_2} > K_{c_1}$$

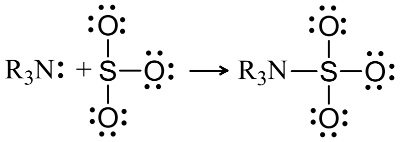
395 **(d)**
$\Delta n = 0$
$\therefore K_p = K_c$

396 **(c)**
Explanation is correct reason for statement

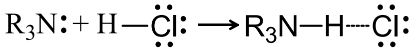
397 **(c)**
K depends only upon temperature

398 **(a)**

Both (A) and (R) are correct and (R) is the correct explanation of (A)



Sulphur can expand its electron complement in the valence shell to exceed the octet. In any case, S, expands its number of valence electrons by attaching to the lone pair on the N and (N − S) bond is more polar bond due to the big difference in EN between N and S



$R_3N: + H—Cl: \longrightarrow R_3N—H---Cl:$

In this case H of the HCl attaches to the lone pair on the N. Here Cl is connected to N by a hydrogen bond

399 **(c)**

Ice ⇌ water, increase in pressure leads to melting of ice as it favours the change showing decrease in volume.

400 **(b)**

$HgI_2 + KI \rightarrow K_2[HgI_4]$ (A) is true

(R) is also true since $I^{\ominus}$ ion is large sized and therefore is highly polarisable. But (R) is not the correct explanation of (A)

401 **(d)**

(A) is wrong because addition of NaCN to HCN, due to common ion $(CN^{\ominus})$, the degree of dissociation of HCN is suppressed and hence less $[H^{\oplus}]$ and increase in pH. (R) is correct

402 **(b)**

The dissociation of NH_4OH is suppressed in presence of NH_4Cl and thus pH of NH_4OH decreases

403 **(a)**

$B(OH)_3 + H_2O \rightleftharpoons B(OH)_4^- + H^+$

404 **(a)**

Both (A) and (R) are correct and (R) is the correct explanation of (A)

$$\underset{\text{Base}}{H_2SO_4} + \underset{\text{Acid}}{HClO_4} \longrightarrow \underset{C_B}{ClO_4^{\ominus}} + \underset{C_A}{H_3SO_4^{\oplus}}$$

406 **(d)**

Increase in pressure favours melting of ice into water because at higher pressure melting point of ice is lowered

407 **(a)**

(A) is true:

$HCl + CH_3COONa \rightarrow CH_3COOH + NaCl$

1 M 2 M 1 M

$[CH_3COONa]_{\text{left}} = 2 - 1 = 1\text{ M}$

So solution contains CH_3COOH and CH_3COONa, an acidic buffer forms

(R) is true

408 **(c)**

Both (A) and (R) are true. A basic buffer is formed whose pH is always > 7

409 **(a)**

Catalyst only increases the rate of reaction

410 **(a)**

Both (A) and (R) are correct and (R) is correct explanation of (A)

411 **(c)**

(A) is correct but (R) is false

Correct (R): K_{sp} of AgCl > K_{sp} of AgBr compounds with lower K_{sp} is precipitated first. Also, for precipitation Q_{sp} should be greater than K_{sp}

414 **(a)**

$$\begin{array}{ccc} PCl_5 & \rightleftharpoons PCl_3 & + Cl_2 \\ \underset{(1-\alpha)}{1} & \underset{\alpha}{0} & \underset{\alpha}{0} \end{array}$$

$$K_p = \left[\frac{\alpha^2}{1-\alpha}\right]\left[\frac{P}{1+\alpha}\right]^1$$

An increase in pressure will decrease α, to have K_p constant and thus backward reaction occurs.

415 **(c)**

Explanation is correct reason for statement.

416 **(c)**

Boiling of a liquid occurs when its vapour pressure becomes equal to atmospheric pressure.

417 **(c)**

This is based on common ion effect

$\text{NaCl} \rightleftharpoons \text{Na}^+ + \text{Cl}^-$

$\text{HCl} \leftrightharpoons \text{H}^+ + \text{Cl}^-$

Concentration of Cl^- ions increases due to ionization of HCl which increases the ionic product$[\text{Na}^+][\text{Cl}^-]$. This results in the precipitation of pure NaCl.

418 **(a)**
According to formula $K_P = K_C(RT)^{\Delta n}$

$\Delta\text{n} = 0$

$\text{K}_\text{P} = \text{K}_\text{c}(\text{RT})^0$

$\text{K}_\text{P} = \text{K}_\text{C}$

419 **(a)**
$K_p = K_c\,(RT)^{\Delta n}$

When $\Delta n > 1, \quad K_p > K_c$

When $\Delta n < 1, \quad K_p < K_c$

When $\Delta n = 0, \quad K_p = K_c$

420 **(d)**
(A) is wrong. It forms acidic buffer and this pH changes

(R) is correct. Due to common ion $(\text{CH}_3\text{COO}^\ominus)$, ionization of CH_3COOH is supressed

421 **(e)**
Both (A) and (R) are wrong

Since it depends on temperature

423 **(c)**
Gas + solvent ⇌ solution; Increase in pressure leads to the change showing decrease in volume.

424 **(a)**
According to Henry's law, "the mass of gas dissolved in a given mass of a solvent at any temperature is directly proportional to the pressure of the gas above the solvent."

425 **(a)**
The scale of pH (0 to 14 at 25°C) changes to (0 to less than 14) as the temperature rises because K_w of water increases with temperature. Note that $[\text{H}^+] = [\text{OH}^-]$ and thus water remains neutral

426 **(d)**
(A) It is acidic (salt of W_B/S_A). So wrong

(R) is correct

$$[\text{A}(\text{H}_2\text{O})_6]^{3+} + \text{H}_2\text{O} \rightleftharpoons [\text{Al}(\text{H}_2\text{O})_5\text{OH}]^{2+} + \text{H}_3\text{O}^\oplus$$

427 **(a)**
The equilibrium $\text{AgCl(s)} \rightleftharpoons \text{Ag}^+ + \text{Cl}^-$

$$K_{sp} = [\text{Ag}^+][\text{Cl}^-]$$

If $[\text{Cl}^-]$ increases, the equilibrium is shifted in the backward direction, *i.e.*, solubility of AgCl decreases in presence of NaCl. Note this is Le Chatelier's principle application to solubility product. In common ion effect, there must be a weak electrolyte

429 **(e)**
(A) $\left[\text{H}^\oplus\right] = \frac{10^{-2}}{2}$ pH = 2.3 not pH = 1

(R) is wrong

430 **(c)**
Addition of inert gas shifts the equilibrium to backward direction

431 **(c)**
(A) is correct because HCl is a strong electrolyte resulting in higher $[\text{H}^\oplus]$ (and less pH) then acetic acid. (R) is wrong, HCl will produce more protons than acetic acid at same concentration

432 **(c)**
(A) is correct

(R) is wrong

Correct (R): Addition of acid or base increase the $[\text{H}^\oplus]$ or $[\overset{\ominus}{\text{O}}\text{H}]$ and thus pH changes

433 **(a)**
Forward reaction increase with temperature only for endothermic reaction, while for exothermic it is reverse

434 **(d)**
(A) is false. $\text{H}^\oplus$ ion from CH_3COOH are adsorbed on characoal thus decrease $[\text{H}^\oplus]$ and hence pH is increased

435 **(a)**

All Bronsted bases are not Lewis bases

436 **(c)**
(A) is correct. Due to common ion ($Cl^{\ominus}$) effect, the suppression of ionization of NaCl occurs and NaCl starts precipitating

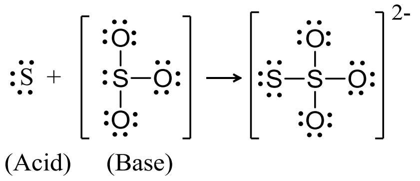
(R) is wrong. Correct (R) as in (A)

438 **(c)**
Explanation is correct reason for statement

439 **(c)**
(A) is true

(R) is false: Correct reason: K_{sp} of CdS $< K_{\text{sp}}$ NiS. Since compound with lower K_{sp} is precipitated first

440 **(a)**
Both (A) and (R) is correct and (R) is correct explanation of (A)



441 **(a)**
Equilibrium constant depends only upon temperature

442 **(d)**
(A) is wrong. Dissociation of water is an endothermic reaction, so increasing T will increase $[H^{\oplus}]$ and hence decrease in pH

(R) is correct

443 **(d)**
In biological systems buffer system of carbonic acid and sodium bicarbonate is found in our blood. It maintains the pH of blood to a constant value of about 7.4

445 **(a)**
The pH of the solution at the neutralisation point region is about 3.5 to 7 and methyl orange gives its colour change between pH 3.1 to 4.4

446 **(c)**
Correct (R): In such very dilute solutions both source of $H^{\oplus}$ ions from HCl and H_2O must be considered and due to common ion ($H^{\oplus}$) supression of ionization occurs

447 **(b)**
Both Assertion and Reason are true statement but Reason is not the correct explanation of Assertion. pH of a buffer solution is given by Henderson-Haselbalch equation.

$$\text{pH} = \text{p}K_a + \log\frac{[\text{salt}]}{[\text{acid}]}$$

$$\therefore \quad \text{pH} = \text{p}K_a \text{ (when [salt]=[acid])}$$

449 **(c)**
CO is acid, NaOH is base and salt formed is HCOONa

450 **(d)**
$Q < K_c$ forward reaction
$Q > K_c$ backward reaction
$Q = K_c$ if $\Delta G = 0$

451 **(c)**
(A) is correct but (R) is false

Correct (R): Sb^{3+} is precipitated in group II B by H_2S in acidic medium (dil HCl). In acidic medium $[S^{2-}]$ decreases so that the radicals of group IV are not precipitated. Since the K_{sp} of the sulphides of II group is less than the K_{sp} of the sulphides of IV group

452 **(a)**
Aqueous solution of $FeCl_3$ on standing produce brown ppt. Due to hydrolysis, it produces ppt of $Fe(OH)_3$ which is of brown colour. Hence, both are correct and reason is a correct explanation

453 **(a)**
Both factual statements

454 **(b)**
(A) is correct. At midpoint of titration of weak acid, [salt] = [Acid] and therefore pH = pK_a

(R) is correct but not the reason of (A)

455 **(b)**
Breaking up of bonds is endothermic

456 **(a)**
If volume is not constant the addition of inert gas affect the equilibrium constant. Both at constant volume, the addition of inert gas has no effect on the state of equilibrium.

457 **(d)**

(A) only reaction (i) is Lewis acid-base reaction, hence (A) is wrong

(R) is correct

458 **(a)**

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

$$\mathrm{K_c} = \frac{\mathrm{mol^2 \times L \times L^3}}{\mathrm{L^2 \times mol \times mol^3}}$$

$$= \mathrm{L^2\ mol^{-2}}$$

459 **(c)**
(A) is correct

Since K_w at 25°C $= 10^{-14}$

So pH of acidic solution < 7 at 25°C

(R) is wrong. pH of 10^{-8}M HCl $= 6.98$

460 **(c)**
Explanation is correct reason for statement

462 **(c)**
Explanation is correct reason for statement.

463 **(c)**
Inert gas addition at constant pressure leads to an increase in volume. To have K_c constant 'α' must decrease.

464 **(c)**

$$\begin{array}{cccc} \mathrm{NaCN} + & \mathrm{HCl} \longrightarrow & \mathrm{NaCl} + & \mathrm{HCN} \\ 0.1 & 0.05 & 0 & 0 \\ 0.05 & 0 & 0.05 & 0.05 \end{array}$$

The solution contains a weak acid HCN and its salt NaCN and thus acts as buffer

465 **(a)**
HCl is regarded as an acid only when dissolved in water and not in any other solvent

466 **(c)**
Explanation is correct reason for statement

467 **(a)**

$$\mathrm{CH_3COONa + H_2O \rightarrow CH_3COOH + NaOH}$$

The above process takes place in following steps

$$\mathrm{CH_3COONa} \underset{\text{in aqueous solution}}{\overset{\text{Ionisation}}{\rightleftharpoons}} \underset{\text{Strong base}}{\mathrm{CH_3COO^- + Na^+}}$$

$$\mathrm{CH_3COO^- + H_2O \longrightarrow CH_3COOH + OH^-}$$

Acetate ion undergoes anionic hydrolysis and the resulting solution is slightly basic due to excess of $\mathrm{OH^-}$ ions. Hence, both Assertion and Reason are true and Reason is the correct explanation of Assertion.

468 **(d)**

$$\mathrm{BaSO_4}(s) \rightleftharpoons \mathrm{Ba^{2+} + SO_4^{2-}}$$

$$s \qquad s + 0.1$$

$$K_{\mathrm{sp}} = (s)(s + 0.1)$$

$$s < 10^{-9}$$

469 **(b)**
Heat of neutralisation of HF and NaOH is −16.4 kcal/eq. due to extensive hydration of $\mathrm{F^-}$ of NaF on account of its smaller size

470 **(c)**
Explanation is correct reason for statement

471 **(a)**
$K_w = 10^{-13}$ at 60°C ∴ pH $= 6.5$; but water is neutral because pH scale contracts to 0 to 13

472 **(a)**
Assume, (a) is true, hence reaction must be endothermic

473 **(c)**
(A) is correct. It exists as Zwitter ion

(R) is wrong. The conjugate acid is $\overset{\oplus}{\mathrm{N}}\mathrm{H_2CH_2COOH}$

474 **(c)**
Explanation is correct reason for statement.

475 **(a)**
Here 0.1 M $\mathrm{H_2S}$ is passed into the solution directly. Selectively precipitation of $\mathrm{Pb^{2+}}$, $\mathrm{Zn^{2+}}$ and $\mathrm{Ni^{2+}}$ is not possible, as the ionic product of their respective sulphides is more than their K_{sp} values and $\mathrm{S^{2-}}$ ion is not added slowly or dropwise

If $\mathrm{H_2S}$ is passed into the solution containing only $\mathrm{H_2O}$, then

$[\mathrm{S^{2-}}] = K_2$ of $\mathrm{H_2S} = 10^{-14}$ M

But in 0.1 M HCl solution

$$K_1 \times K_2 = \frac{[H^{\oplus}]^2[S^{2-}]}{H_2S}$$

$$10^{-7} \times 10^{-14} = \frac{(0.1)[S^{2-}]}{0.1} \quad \therefore [S^{2-}] = 10^{-20}M$$

$\therefore Q_{sp}$ of PbS and $ZnS(0.1 \times 10^{-20}) > K_{sp}$ of PbS and ZnS (Hence both precipitate) Q_{sp} of $NiS(10^{-21}) < K_{sp}$ of NiS (Hence do not precipitate)

476 **(e)**
Both (A) and (R) are false

Correct (A): For titration of S_B/W_A (pH change near the end point $8-10$), phenolphthalein or thymol blue are used

Correct (R) methyl orange changes colour in pH range (3 to 4.5)

477 **(b)**
$RCOONa \longrightarrow RCOO^- + Na^+$; In presence of NaCl, $[Na^+]$ increases and $[RCOO^-][Na^+]$ exceeds than K_{sp} of $RCOONa$

478 **(a)**
Both (A) and (R) are correct and (R) is the correct of explanation of (A). Zn^{2+} is precipitated as ZnS in basic medium

479 **(b)**
$\Delta G^{\circ} \neq 0$ at equilibrium
$\Delta G = 0$ at equilibrium

480 **(c)**
Explanation is correct reason for statement

481 **(a)**
The state of equilibrium is not affected by the addition of noble gases, at constant volume

482 **(b)**
According to Le-Chatelier's principle with increase of pressure, equilibrium shifts in that direction in which lesser number of gaseous moles are produced

483 **(d)**
$N_2 + 3H_2 \rightleftharpoons 2NH_3 + \text{Heat}$

This reaction is favoured by decrease of temperature, increase of pressure, addition of catalyst and promoter

484 **(a)**
Statement is correct due to back bonding in boron. In nitrogen halides the order is $NF_3 < NCl_3 < NBr_3 < NI_3$. On account of decreasing electronegativity to halogens. In NF_3, the lone pair is not released easily, due to more +ve charge on N

485 **(c)**
The value of K depends on the stoichiometry of reactants and products at the point of equilibrium. For example if the reaction is multiplied by 2, the equilibrium constant is squared

486 **(c)**
According to Le-chateliers principle endothermic reaction favours increase in in temperature . However exothermic reaction favour decrease in temperature.

487 **(a)**

$$AgCN(s) \rightleftharpoons Ag^{\oplus} + CN^{\ominus}$$

$$CN^{\ominus} + H^{\oplus} \longrightarrow HCN$$

As $CN^{\ominus}$ ions are consumed by $H^{\oplus}$ ions to form a W_A, HCN, more AgCN is dissolved

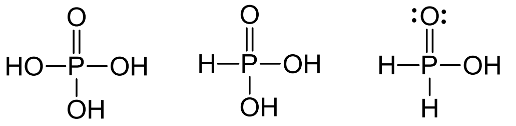
488 **(a)**
$CO(H_2O)_6^{2+}$ (pink) while $CoCl_4^{2-}$ (blue); so on cooling because of Le-Chatelier's principle the reaction tries to overcome the effect the temperature.

489 **(d)**
In endothermic reaction, on increasing the temperature, reaction shifts to forward direction

490 **(d)**
Blood is alkaline and at body temperature (98°F) scale of pH lies between 0 to 13.6

491 **(e)**
K_p can be greater, less or equal to K_c

492 **(a)**
Both (A) and (R) are correct and (R) is the correct explanation of (A). Structure are:



(H_3PO_4) (H_3PO_4) (H_3PO_2)
(Tribasic acid) (Dibasic acid) (Monobasic acid)

(In all the three acids, number of terminal oxygen atoms is one)

493 **(b)**

(A) is correct. Salt of $H_2S_2O_3$ and NaOH. H_2SO_3 is unstable acid

(R) is correct but not the correct explanation of (A)

494 **(c)**

Solid ⇌ Liquid $V_L > V_S$; Ice ⇌ water, increase in pressure leads to melting of ice as it favours the change showing decrease in volume.

495 **(a)**

(**a**→**q**) Salt of W_A/S_B pH $= \frac{1}{2}(\mathrm{p}K_w + \mathrm{p}K_a + \log C)$

$= \frac{1}{2}(14 + \mathrm{p}K_a + \log 10^{-1})$

$= 6.5 + \frac{1}{2}\mathrm{p}K_a$

(**b**→**r**) Salt of W_B/S_A, pH $= \frac{1}{2}(\mathrm{p}K_w - \mathrm{p}K_a - \log C)$

$= \frac{1}{2}(14 - \mathrm{p}K_b - \log 10^{-1})$

$= 7.5 - \frac{1}{2}\mathrm{p}K_a$

(**c**→**p**) Salt of S_A/S_B, (do not hydrolyse), pH = 7

(**d**→**p,s**) salt of W_A/W_B

pH $= \frac{1}{2}(\mathrm{p}K_w + \mathrm{p}K_a - \mathrm{p}K_b)$

$= 7 + \frac{1}{2}\mathrm{p}K_a - \frac{1}{2}\mathrm{p}K_b = 7$ since ($\mathrm{p}K_a = \mathrm{p}K_b$)

497 **(a)**

(**a**→**q**)NH_4Cl: only $\overset{\oplus}{NH_4}$ will get hydrolysed

(**b**→**r**) CH_3COONa: only $CH_3COO^{\ominus}$ will get hydrolysed

(**c**→**s**) NH_4CN: Both $\overset{\oplus}{NH_4}$ and $CN^{\ominus}$ will get hydrolysed

(**d**→**p**) NaCl: Neither $Na^{\oplus}$ and $Cl^{\ominus}$ will get hydrolysed

498 **(d)**

(**a**→**p**) Acidic salt: aqueous solution of salt is acidic

(pH < 7)pH $= \frac{1}{2}(\mathrm{p}K_w - \mathrm{p}K_b - \log C)$

(**b**→**q**) Basic salt: Aqueous solution of salt is basic

(pH > 7)pH $= \frac{1}{2}(\mathrm{p}K_w + \mathrm{p}K_b + \log C)$

(**c**→**s**) Acidic buffer: pH $= \mathrm{p}K_a + \log\frac{[\text{Salt}]}{[\text{Acid}]}$

(**d**→**r**) Basic buffer: pOH $= \mathrm{p}K_b + \log\frac{[\text{Salt}]}{[\text{Base}]}$

499 **(a)**

$$HSO_4^{\ominus} + H_2O \longrightarrow H_3O^{\oplus} + SO_4^{2-}$$
(Bronsted acid)

(a→r,s) $HSO_4^{\ominus} + H^{\oplus} \longrightarrow H_2SO_4$ (Bronsted base)

(b→p) BF_3 (e^- deficient and hence Lewis acid)

(c→q,s) H_3N: (It can donate lone pair of electrons and acts as Lewis base)

$NH_3 + H_2O \longrightarrow \overset{\oplus}{NH_4} + \overset{\ominus}{OH}$ (Accepts $H^{\oplus}$ and acts as Bronsted base)

(d→q,s) $\overset{\ominus}{OH}$ (It is bronsted base by accepting $^{\oplus}$) It can donate lone pair of electrons and acts as Lewis base also

500 **(b)**

(**a**→**p**) Acidic buffer (mixture of W_A + salt of W_A/S_B)

pH $= \mathrm{p}K_a + \log\left(\frac{\text{Salt}}{\text{Acid}}\right)$

$= 4.74 + \log\left(\frac{0.1}{0.1}\right) = 4.74$

Thus, it is acidic buffer at maximum buffer capacity. Because buffer limits are pH ± 1. When pH = pK_a, it is a buffer at maximum buffer capacity

(**b**→**r**) It is mixture of W_A and S_A. So pH of 0.1 M HCl will predominate and pH > 7

(**c**→**s**) It will forms salt of W_A/W_B. Since $\mathrm{p}K_a = \mathrm{p}K_b$, Thus pH = 7. $\Big($pH $= \frac{1}{2}(\mathrm{p}K_w + \mathrm{p}K_a +$ pKb

(**d**→**q**) mmol of $CH_3COONa = 300 \times 0.1 = 30$
mmol of HCl $= 100 \times 0.1 = 10$
$CH_3COONa +$ HCl → CH_3COOH + NaCl
Initial 30 mmo10 mmol 0 0
Final $(30 - 10) = 20$ $(10 - 10) = 0$ 10 −

501 **(b)**

(**a**→**r**) A $\xrightarrow{K_1}$ B for reverse reaction B $\xrightarrow{K}$ A;

$K = \frac{1}{K_1}$

(**b** →**p**) $K = (\mathrm{K})^{1/2}$

(**c** → **b**) $K = K^2$

502 **(c)**

All factual statements

503 **(c)**

For $A + B \rightleftharpoons [AB]$

$$K_c = \frac{[A]\,[B]}{[AB]} = \frac{[\text{mol L}^{-1}]\,\cancel{[\text{mol L}^{-1}]}}{\cancel{[\text{mol L}^{-1}]}} = [\text{mol L}^{-1}]$$

Hint:

Use above expression for all equation

504 **(c)**

For $A + B \rightleftharpoons [AB]$

$$K_c = \frac{[A]\,[B]}{[AB]} = \frac{[\text{mol L}^{-1}]\,\cancel{[\text{mol L}^{-1}]}}{\cancel{[\text{mol L}^{-1}]}} = [\text{mol L}^{-1}]$$

Hint:

Use above expression for all equation

506 **(b)**

	V_{NaOH}	mmol H_2S in excess	mmol $HS^\ominus$ produced	mmol S^{-2} produced	pH
a.	0.001	1.00	0.00	–	4.5
b.	0.5	0.5	0.5	–	7.0
c.	1.0	0.0	1.0	0.0	9.5 and 12.0
d.	1.5	–	0.5	0.5	11.7

$H_2S + H_2O \rightarrow HS^\ominus + H_2O;$

$$\Rightarrow K_1 = \frac{[H_3O^\oplus][HS^\ominus]}{[H_2S]} = 10^{-7}$$

$HS^\ominus + H_2O \rightarrow H_3O^\oplus + S^{2-}$

$$\Rightarrow K_2 = \frac{[H_3O^\oplus][S^{2-}]}{[HS^\ominus]} = 10^{-14}$$

The total volume of the titration mixture will change only slightly. Titrations (a) and (b) is calculated directly from the K_1 value of H_2S

(a→q) $\frac{x\times x}{0.01} = 10^{-7}$ so $x = [H_3O^\oplus] = 3.1\times10^{-5}$ and pH $= 4.5$

(b→p) $\frac{x(0.5)}{0.5} = 10^{-7}$, so pH $= 7.0$

(c→r,t)

i. Point (c) is the first equivalence point the same solution as 1.0 mol of NaHS in 101.0 mL. The $HS^\ominus$ can react in water to ionize is either of the two ways:

$HS^\ominus + H_2O \longrightarrow H_3O^\oplus + S^{2-}\ (K_2 = 10^{-14})$ ...(i)

$HS^\ominus + H_2O \longrightarrow \overset{\ominus}{O}H + H_2S$ ...(ii)

$$K_h = \frac{K_w}{K_1} = \frac{10^{-14}}{10^{-7}} = 10^{-7}$$

Equation (ii) will predominate, therefore ignore equation (i)

Hence, this case becomes the hydrolysis of salt of W_A/W_B. Considering K_1 of H_2S. ($pK_aH_2S = 7$)

$$\therefore \text{pH} = \frac{1}{2}(pK_w + pK_1 + \log C)$$

$$= \frac{1}{2}\left(14 + 7 + \log\frac{1}{101}\right)$$

$$= \frac{1}{2}(14 + 7 + \log 10^{-2})$$

$$= \frac{1}{2}(14 + 7 - 2) = 9.5$$

ii. With $HS^\ominus$ hydrolyzing much more than ionizing to yield $H_3O^\oplus$, it might be well to calculate the hydrolysis of S^{2-} at the second equivalence point

$$S^{2-} + H_2O \longrightarrow HS^\ominus + \overset{\ominus}{O}H,\ K_h = \frac{K_w}{K_2} = \frac{10^{-14}}{10^{-14}} = 1$$

$$\therefore \frac{x^2}{0.01 - x} = 1 \text{ or } x^2 + x - 0.01 = 0$$

$\frac{-1+\sqrt{1+0.04}}{2} = 1\times10^{-2}\ \overset{\ominus}{O}H$ thus pOH $= 2$, pH $=$ 12.0

The extra $\overset{\ominus}{O}H$ ions added after the first equivalence point have not been neutralized by the very weak $HS^\ominus$ ion, ion, i.e., titration is some what like that of weak acid (CH_3COOH)

(d→s) When 1.5 mL of NaOH added: (Total volume $= 100 + 1.5 = 101.5 \approx 100$ mL)

$$[S^{2-}]_{\text{initial}} = \frac{0.5}{100} = 0.5\times10^{-2} \text{ or } 5\times10^{-3}$$

$$[HS^\ominus]\ \text{initial} = \frac{0.5}{100} = 0.5\times10^{-3}$$

$$S^{2-} + H_2O \longrightarrow HS^\ominus + \overset{\ominus}{O}H$$

Initial 5×10^{-3} – 5×10^{-3} 0

At equilibrium $(5\times10^{-3} - x)$ – $(5\times10^{-3} +$ x x

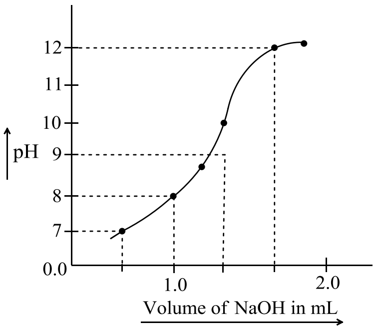
$$K_h = \frac{K_w}{K_2} = \frac{10^{-14}}{10^{-14}} = 1$$

$$\therefore K_h = \frac{[HS^\ominus][\overset{\ominus}{O}H]}{[S^{2-}]}$$

$$1 = \frac{(5\times10^{-3} + x)\,x}{(5\times10^{-3} - x)}.\ \text{Thus } x = 5\times10^{-3} = [\overset{\ominus}{O}H]$$

pOH $= 2.3$ and pH $= 11.7$

Graphical representation



507 **(a)**

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

$\therefore K_p = K_c$

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

$\therefore K_p = K_c(RT)^{-2}$

(**c→p**) $K_p = K_c(RT)^{\Delta n}; \Delta n = 2-1 = 1$

$\therefore K_p = K_c(RT)$

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

$\therefore K_p = K_c(RT)^2$

508 **(a)**

$$\underset{}{Li_3Na_3(AlF_6)_2} \rightleftharpoons \underset{3x}{3Li^{\oplus}} + \underset{3x}{3Na^{\oplus}} + \underset{3x}{2(AlF_6)^{-3}}$$

(a→q)

$K_{sp} = 3^3 3^3 2^2 x^8 = 2916\, x^8$

(b→t) $\underset{}{Zr_3(PO_4)_4} \rightleftharpoons \underset{3x}{3Zr^{+4}} + \underset{4x}{4PO_4^{3-}}$

$K_{sp} = 3^3 4^4 x^7 = 6912 x^7$

(c→p) $Bi_2S_3 \rightleftharpoons \underset{2x}{2Bi^{3+}} + \underset{3x}{3S^{2-}}$

$K_{sp} = 2^2 3^3 x^5 = 108 x^5$

$$Al(OH)_3 \rightleftharpoons \underset{x}{Al^{3+}} + \underset{3x}{3\overset{\ominus}{OH}}$$

(d→r)

$K_{sp} = 1^1 3^3 x^4 = 27 x^4$

(e→s) $CaF_2 \rightleftharpoons \underset{x}{Ca^{3+}} + \underset{3x}{2F^-}$

$K_{sp} = 1^2 2^3 x^3 = 4x^3$

509 **(a)**

(**a→s**) At equilibrium $Q = K$

(**b→q,r**) When $Q < K$, reaction proceeds in forward direction

(**c→q,t**) When $Q > K$, reaction proceeds in backward direction

(**d→p**) When $K >> 1$, reaction is about to complete

510 **(a)**

(**a→s**) At equilibrium $Q = K$

(**b→q,r**) When $Q < K$, reaction proceeds in forward direction

(**c→q,t**) When $Q > K$, reaction proceeds in backward direction

(**d→p**) When $K >> 1$, reaction is about to complete

511 **(a)**

According to le-chatelier principle, on increasing the pressure the reaction shift in the direction which have lesser number of molecules

512 **(c)**

($\boldsymbol{a}$ →**q**) S in buffer $= \left[K_{sp}\left(1 + \frac{H^{\oplus}}{K_a}\right)\right]^{1/2}$

S in $H_2O = \sqrt{K_{sp}}$

$\frac{S \text{ in buffer}}{S \text{ in } H_2O}$

$$\frac{\sqrt{K_{sp}}\left(1 + \frac{H^{\oplus}}{K_a}\right)^{1/2}}{\sqrt{K_{sp}}} = \left(1 + \frac{10^{-3}}{10^{-3}/3}\right)^{1/2} = 2$$

($\boldsymbol{b}$ →**p**) $\frac{S \text{ in buffer}}{S \text{ in } H_2O}$

$$= \left(1 + \frac{H^{\oplus}}{K_a}\right)^{1/2} = \left(1 + \frac{10^{-4}}{10^{-4}/7}\right)^{1/2} = 4$$

($\boldsymbol{c}$ →**p**) $\frac{S \text{ in buffer}}{S \text{ in } H_2O}$

$$= \left(1 + \frac{H^{\oplus}}{K_a}\right)^{1/2} = \left(1 + \frac{10^{-5}}{10^{-5}/8}\right)^{1/2} = 3$$

($\boldsymbol{d}$ →**q**) S in 0.1 M HCl $= \frac{K_{sp}}{0.1}$

S in 0.02 M $AgNO_3 = \frac{K_{sp}}{0.2}$

$$\frac{S \text{ in HCl}}{S \text{ in } AgNO_3} = \frac{K_{sp} \times 0.2}{0.1 \times K_{sp}} = 2$$

(**e→r**) S in 0.1 M HCl $= \frac{K_{sp}}{(0.1)^3}$

S in 0.2 M NaOH $= \frac{K_{sp}}{(0.2)^3}$

$$\frac{S \text{ in 0.1 MHCl}}{S \text{ in 0.2 M NaOH}} = \frac{K_{sp} \times (0.2)^3}{(0.1)^3 \times K_{sp}} = 8$$

513 **(a)**

(**a→p,r**) It is endothermic reaction hence on increasing temperature reaction proceed in forward direction. On addition of inert gas, at constant pressure also favour product side according to le-Chatelier principle

(**b** →**q,r,s**) It is exothermic reaction hence on increasing temperature reaction proceed in backward direction

(**c**→**p**) Endothermic reaction therefore on increasing temperature reaction proceed in product side

(**d**→**s**) Exothermic reaction therefore on increasing temperature reaction proceed in backward side

514 **(c)**

According to Le Chatelier principle endothermic reaction proceed in forward direction on increasing temperature while the exothermic reaction proceed in backward direction on increasing temperature

515 **(b)**

(**a→p,t**) Only $\overset{\oplus}{\text{NH}_4}$ will get hydrolysed (cation hydrolysis) pH < 7

$$\text{pH} = \frac{1}{2}(\text{p}K_w - \text{p}K_b - \log C)$$

(**b→s,t**) It is a S_A. $\text{pH} = 2$, New conc $= \frac{10^{-2}}{10} = 10^{-3}$, $\text{pH} = 3$

(**c→r**) It is a W_B, so $\text{pH} > 7$

(**d→p,q**) Salt of W_A/W_B both $\text{CH}_3\text{COO}^{\ominus}$ and $\overset{\oplus}{\text{NH}_4}$ will hydrolysed so both cationic and anionic hydrolysis

519 **(a)**

	V_{NaOH} mL	V_{total} mL	mmol of CH_3COOH in excess	mmol of salt ($\text{CH}_3\text{COO}^{\ominus}$) produced	mmol of $\overset{\ominus}{\text{OH}}$ in excess	Type
a.	25.0	25+50=75	2.5	2.5	–	Acidic buffer
b.	40.0	40+50=90	1.0	4.0	–	Acidic buffer
c.	50.0	50+50=100	0.00	5.0	–	Salt of W_A/W_B
d.	60.0	60+50=110	–	5.0	1.0	S_B
e.	70.0	70+50=120	–	5.0	2.0	S_B

(**a→r**) $\text{p}H = \text{p}K_a + \log\frac{[\text{Salt}]}{[\text{Acid}]}$

$$4.74 + \log\left(\frac{2.5/75}{2.5/75}\right) = 4.74$$

(b→q) $\text{pH} = pK_a + \log\left(\frac{4.0/90}{2.5/90}\right) = 4.74 + 0.6 = 5.34$

(c→t) $\text{pH} = \frac{1}{2}(\text{p}K_w + \text{p}K_a + \log C)$

$$\frac{1}{2}\left(14 + 4.74 + \log\frac{5}{100}\right) = 8.72$$

$$[\overset{\ominus}{\text{OH}}] = \frac{1.0 \text{ mmol}}{110 \text{ mL}} = 9.1 \times 10^{-3} \text{ M}$$

(d→q)

$\text{pOH} = 2.04, \text{pH} = 11.96$

$$[\overset{\ominus}{\text{OH}}] = \frac{2.0 \text{ mmol}}{120 \text{ mL}} = 1.7 \times 10^{-2} \text{ M}$$

(e→s)

$\text{pOH} = 1.78, \text{pH} = 12.22$

520 **(c)**

(a→q) Basic buffer is formed

mmol of HCl added $= 2.0 \times 1L = 2$

mmol of $\overset{\oplus}{\text{NH}_4}$ formed =2

mmol of NH_3 left

$(1 \times 0.01 \times 10^3 = 10) = 10 - 2 = 8$

$$\text{pOH} = \text{p}K_b + \log\frac{[\overset{\oplus}{\text{NH}_4}]}{[\text{NH}_3]}$$

$$= 4.74 + \log\frac{2}{8} = 4.14$$

$$\frac{[\overset{\oplus}{\text{NH}_4}]}{[\text{NH}_3]} = \left(\frac{5}{5}\right) = 1.0$$

(b→r)

$\text{pOH} = 4.74$

(c→s) In (c) salt of W_B/S_A is formed

$(V_{\text{total}} = 1\,L + 5 \text{ mL} \approx 1 \text{ L})$

$$[\text{NH}_4\text{Cl}] = \frac{0.01}{0.01\,L} \approx 0.01 \text{ M}$$

$$\text{pH} = \frac{1}{2}(\text{p}K_w - \text{p}K_b - \log C)$$

$$= \frac{1}{2}(14 - 4.74 - \log 10^{-2}) = 5.63$$

$\text{pOH} = 14 - 5.63 = 8.37$

(d→p) When 11.0 mL of HCl is added, all the NH_3 is neutralized and 1.0 mmol of HCl is in exess. pH is determined by 1.0 mmol of $\text{H}_3\text{O}^{\oplus}$ in 1.01 L

$$[\text{H}_3\text{O}^{\oplus}] = \frac{1 \times 10^{-3} \text{ mol}}{1.01\text{L}} \approx 10^{-3},$$

$\text{pH} = 3$, and $\text{pOH} = 11$

521 **(b)**

(c→r, s)

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

$$\therefore K_p = K_c\,(RT)^{-2} \text{ or } K_c > K_p$$

522 **(b)**

(c→r, s)

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

$$\therefore K_p = K_c\,(RT)^{-2} \text{ or } K_c > K_p$$

523 **(b)**

(**a**→**p**) $\Delta n = n_P - n_R > 0$; the number of molecules in product side are higher than reactant side hence according to Le-Chatelier principle on increasing the pres equilibrium shift to lesser number of molecules side

(**b** →**r**) When there is no change in volume $(\Delta V = 0)$ then addition of inert gas does not change the equilibrium

(**c**→**s**)$K_p = K_c(RT)^{\Delta n}$, when $\Delta n = 0$

$$\therefore K_p = K_c(RT)^{\circ} \text{ or } K_p = K_c$$

(**d**→**q**)

525 **(a)**

$\text{N}_2\text{O}_4 \rightleftharpoons 2\text{NO}_2$

1	0	initial
$1 - x$	$2x$	at equilibrium

Total no. of moles $= 1 - x + 2x = 1 + x$

$$K_p = \frac{4x^2}{(1-x)} \times \left[\frac{p}{1+x}\right]^{\Delta n_g}$$

$$640 = \frac{4x^2}{(1-x)} \cdot \frac{160}{(1+x)}$$

$x = 0.707$ or 70.7%

526 **(d)**

$$\text{CaCO}_3(s) \overset{\Delta}{\rightleftharpoons} \text{CaO}(s) + \text{CO}_2(\text{g}) \quad K_{p_1} = 8 \times 10^{-2}$$

$$\text{CO}_2(\text{g}) + \text{C}(s) \rightarrow 2\text{CO}(\text{g}) \quad K_{p_2} = 2$$

$$K_p'''' = K_{p_1} \times K_{p_2}$$

$$= 8 \times 10^{-2} \times 2 = 16 \times 10^{-2}$$

$$K_p'''' = \left(p_{\text{CO}}(\text{g})\right)^2$$

$$p_{\text{CO}} = \sqrt{K_p''''} = \sqrt{16 \times 10^{-2}} = 4 \times 10^{-1}$$

$$= 0.4 \text{ atm}$$

527 **(b)**

$$\% \text{ of unprecipitatedAg}^+ = \frac{\text{unprecipitated Ag}^+}{\text{total Ag}^+ \text{ taken}} \times 100$$

$$= \frac{1 - \left(\frac{149}{150}\right)}{1} \times 100$$

$= 0.666\%$

528 **(b)**

On adding H_2SO_4, $[H^+]$ increases. Therefore, to keep K_w constant, $[OH^-]$ decreases

529 **(a)**

Shifts in the product side

530 **(b)**

Addition of Ni^{2+} causing more blue colour means reaction moving in the forward direction

$\Rightarrow [Ni(NH_3)_6]^{2+}$ has increased and NH_3 (unreacted) was present initially

531 **(b)**

$NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g)$;

27×10^{-2}

$K_c = 27 \times 10^{-2} X = 8.91 \times 10^{-2}$

$$X = \frac{8.91 \times 10^{-2}}{2.7 \times 10^{-1}} = 3.3 \times 10^{-1}$$

Number of mol of $NH_3 = 0.27$

$H_2S = 0.33$

$N_2 = 0.03$

$H_2 = 0.09$

$$X_{H_2} = \frac{0.09}{0.72} = \frac{1}{8}$$

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

$3a \qquad \frac{1}{3}a \qquad a$

$$K_c = \frac{(a/3)a^3}{(3a)^2} = \frac{a^4}{3} \times \frac{1}{9a^2}$$

$$\frac{a^2}{27} = 3 \times 10^{-4}$$

$\therefore\ a^2 = 81 \times 10^{-4}$

$a = 9 \times 10^{-2}$

533 **(b)**

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

535 **(b)**

$$P_{NH_3} = P_{HCl} = \frac{0.820}{2} \text{ bar}$$

$\therefore K_p = P_{NH_3} \times P_{HCl} = 0.41 \times 0.41 = 0.168$

536 **(a,b)**

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

537 **(a)**

$K_3 = K_1 \times K_2$

538 **(d)**

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

$$= K_c(RT)^{-2} = \frac{K_c}{[(0.082) \times (300)]^2}$$

539 **(c)**

When $Q > K$, the reaction proceeds in backward direction

540 **(b)**

$CuSO_4 \cdot 5H_2O \rightleftharpoons CuSO_4 \cdot 3H_2O + 2H_2O(g)$

$p_{H_2O} = 7.8$ mm

$\Rightarrow K_p = \left(p_{H_2O}\right)^2 = (7.8)^2 = 60.84$

541 **(c)**

The concentration of $[Y]$

is constant $\Rightarrow$ y must be solid. The concentration of X decreases white the concentration of Z increases

Therefore X must be reactant and Z must be product

$\therefore$ (c)

542 **(a)**

$X(s) \rightleftharpoons A(g) + C(g)$;

$\qquad 20 \text{ mm} \quad 20 \text{ mm}$

$K_{P_1} = 20 \times 20 = 400 \text{ mm}^2$

and

$Y(s) \rightleftharpoons B(g) + C(g)$;

$\qquad 30 \text{ mm} \quad 30 \text{ mm}$

$K_{p_2} = 30 \times 30 = 900 \text{ mm}^2$

$$\therefore \frac{K_{p_1}}{K_{p_2}} = \frac{4}{9}$$

Hence, (a) is the correct answer

543 **(b)**

$2KIO_3 + Pb(NO_3)_2 \rightarrow Pb(IO_3)_2 + 2KNO_3$

$0.8 \times 15 \quad 35 \times 0.15$

$= 12 \qquad = 5.25$

544 **(b)**

(a) and (c) are not true since at equivalence point, they represent neutral solution

(d) is clearly wrong, since, $K_w = [H^{\oplus}]\,[\overset{\ominus}{OH}]$

(b) is correct

545 **(b)**

Since K_{a_1} and K_{a_2} are high values therefore point A, K_{a_1} and K_{a_2} are considered

$H_3A \rightleftharpoons H^{\oplus} + H_2A^{\ominus}$

$H_2A^{\ominus} \rightleftharpoons H^{\oplus} + HA^{2-}$

$$K_{a_1} + K_{a_2} = \frac{[H^{\oplus}][HA^{2-}]}{[H_3A]} \begin{bmatrix} \text{At equivalence point} \\ [HA^{2-}] = [H_3A] \end{bmatrix}$$

$-\log K_{a_1} - \log K_{a_2} = -2\log[H^{\oplus}]$

$pK_{a_1} + pK_{a_2} = 2\text{pH}$

$$\therefore \text{pH} = \frac{pK_{a_1} + pK_{a_2}}{2} = \frac{3+5}{2} = 4$$

546 **(c)**

$[S^{2-}]_{\min}$ for SnS $= \dfrac{K_{sp}(\text{SnS})}{[Sn^{2+}]}$;

$[S^{2-}]_{\min}$ for CdS $= \dfrac{K_{sp}(\text{CdS})}{[Cd^{2+}]}$;

$[S^{2-}]_{\min}$ for NiS $= \dfrac{K_{sp}(\text{NiS})}{[Sn^{2+}]}$;

and $K_{sp}(\text{NiS}) < K_{sp}$ (SnS) $< K_{sp}(\text{CdS})$

$\therefore$ NiS will precipitate first

547 **(a)**

Use: $\frac{\alpha_1}{\alpha_2} = \sqrt{\frac{C_2}{C_1}} \Rightarrow \frac{4.24}{\alpha_2} = \sqrt{\frac{0.1}{0.01}}$

$\Rightarrow\ \alpha_2 = \dfrac{4.24}{\sqrt{10}}\% = 1.33\%$

548 **(c)**

i. On dilution (equal volume) and if there were no precipitation. $[NO_3^\ominus] = [Ag^\oplus] = [Cl^\ominus] = [Br^\ominus] = \frac{0.01}{2} = 0.005\text{ M} = 5.0 \times 10^{-3}\text{ M}$

AgBr is the more soluble salt (less Ksp means more soluble) and would take precedence in the precipitating reaction

ii. Assume AgCl does not precipitate. In this case $Ag^\oplus$ and $Br^\ominus$ would be removed by precipitation and the concentration of these two ions in solution would remain equal to each other

iii. $[Ag^\oplus] = [Br^\ominus] = \sqrt{K_{sp}\text{ AgBr}} = (5.0 \times 10^{-13})^{\frac{1}{2}}$
$= 7.1 \times 10^{-7}$ M

iv. Q_{sp} or I.P. of AgCl $= [Ag^\oplus][Cl^\ominus]$
$= (7.1 \times 10^{-7})(5.0 \times 10^{-3}\text{M}) = 3.5 \times 10^{-9}$

Q_{sp} of AgCl $> K_{sp}$ of AgCl, ($\therefore$ Some AgCl most also precipitate)

Hence the assumption in (ii) is wrong

v. Since both holides precipitate, it is a case of simultaneous solubilities

vi. By electroneutrality

$$[Na^\oplus] + [Ag^\oplus] = [Cl^\ominus] + [Br^\ominus] + [NO_3{}^\ominus]$$

$$0.01 + [Ag^\oplus] = [Cl^\ominus] + [Br^\ominus] + 0.005$$

$$\text{or } [Cl^\ominus] + [Br^\ominus] - [Ag^\oplus] = 0.005 \qquad \ldots(1)$$

vii. $[Ag^\oplus]\,[Cl^\ominus] = 10^{-10}$ ...(2)

$[Ag^\oplus]\,[Br^\ominus] = 5 \times 10^{-13}$ ...(3)

viii. Divide (2) by (3), $\dfrac{[Cl^\ominus]}{[Br^\ominus]} = 200$

This shows $Br^\ominus$ plays a significant role in the total anion concentration of the solution

ix. Moreover, $[Ag^\oplus]$ must be negligible in (1) because of insolubility of two silver salts

x. Therefore assume in (1) that $[Cl^\ominus] = 0.005 = 5 \times 10^{-3}$

$[Cl^\ominus] = 5 \times 10^{-3}$

xi. From (2)

$$[Ag^\oplus] = \frac{10^{-10}}{[Cl^\ominus]} = \frac{10^{-10}}{0.005} = 2.0 \times 10^{-8}$$

549 **(a)**

$$CuCl_2.2H_2O \longrightarrow Cu^{2+} + 2Cl^\ominus + 2H_2O$$

$$Cu^{2+} \quad + \quad Cl^\ominus \quad \longrightarrow CuCl^\oplus$$

Initial mol	1.5	$2 \times 1.5 = (3.0)$	0
At equilibrium	$1.5 - x$	$3.0 - x$	x

$$K_f = \frac{[CuCl^\oplus]}{[Cu^{2+}][Cl^\ominus]} = 1.0$$

$\Rightarrow \dfrac{x}{(1.5-x)(3.0-x)} = 1.0$

$\Rightarrow x = 4.5 - 4.5x + x^2$

$\Rightarrow x^2 - 5.5x + 4.5 = 0$

$x = \dfrac{5.5 \pm \sqrt{(5.5)^2 - 4(4.5)}}{2}, x = 1.0 \text{ or } 4.5$

$[Cu^{2+}] = 0.5$ M

550 **(c)**

By Henry's law

$p_{CO_2} = x_{CO_2}\,K_H$

$x_{CO_2} = \dfrac{pCO_2}{K_H} = \dfrac{(1.25 \times 10^{-4}\text{ atm}) \times 760\text{ torr}}{1.25 \times 10^6\text{ torr}}$

$= 0.76 \times 10^{-7} = \dfrac{n_{CO_2}}{n\text{ Total}}$

$x_{H_2O} = (1 - 0.76 \times 10^{-7}) \approx 1 = \dfrac{n_{H_2O}}{n\text{ Total}}$

$\therefore \dfrac{\frac{n_{CO_2}}{n}\text{Total}}{\frac{n_{H_2O}}{n}\text{Total}} = \dfrac{n_{CO_2}}{n_{H_2O}} = \dfrac{0.76 \times 10^{-7}}{1}$

$\approx 0.76 \times 10^{-7}$

Molality of CO_2 solution

$= \dfrac{x_{CO_2} \times 1000}{x_{H_2O} \times M_w H_2O} = \dfrac{n_{CO_2} \times 1000}{n_{H_2O} \times M_{wH_2O}}$

$= \dfrac{0.76 \times 10^{-7} \times 1000}{18}$

$= 4.22 \times 10^{-6} m \approx 4.22 \times 10^{-6}$ M

$H_2CO_3 \rightleftharpoons H^\oplus + HCO_3^\ominus$

$K = \dfrac{[H^\oplus][HCO_3^\ominus]}{[H_2CO_3]} \approx \dfrac{[H^\oplus]^2}{[H_2CO_3]}$

$\therefore [H^{\oplus}] = \sqrt{K_a[H_2CO_3]}$

$= \sqrt{4.3 \times 10^{-7} \times 4.22 \times 10^{-6}}$

$= \sqrt{1.814} \times 10^{-6}$

1.345×10^{-6} M

pH $= 5.87$

551 **(a)**

$BaCl_2 + H_2SO_3 \rightarrow BaSO_3 + 2HCl$

552 **(c)**

pH of titration of strong acid with strong base is 7

553 **(a)**

$2NH_3 \rightleftharpoons N_2 + 3H_2$

$\underset{(10-2x)}{10} \quad \underset{x}{0} \quad \underset{3x}{0} \quad \underset{\text{at } 620\text{ K}}{\text{at } 300\text{ K}}$

Pressure increase due to increases in temperature as well as due to increase in moles

Initially $P \propto T$

$\therefore \quad 15 \propto 300$

$P \propto 620$

$\therefore \ P = \frac{620}{300} \times 15 = 31$ atm of 10 mole of NH_3 at 620 K Now NH_3 is dissociated to attain 50 atm at 620 K.

Thus, $P \propto n$ or $10 \propto 31$

$10 + 2x \propto 50$

$\therefore \quad 2x = 6.13$

$\therefore \quad \alpha = \frac{2x}{10} \times 100 = \frac{6.13 \times 100}{10} = 61.3\%$

554 **(b)**

The intermediate solution of acid will react with all the NH_3 present in solution

555 **(8)**

c. $CH_3COO^{\ominus} + H_3O^{\oplus} \rightarrow CH_3COOH + H_2O$ (> 98%)

5. $CH_3COO^{\ominus} + H_3O^{\oplus} \rightarrow CH_3COOH + H_2O$ (> 98%)

557 **(4)**

(b), (d), (e), and (f)

All salts (b, d and f), soluble hydroxides and the acid (e) are strong electrolysis

558 **(b)**

We know that $K = \frac{K_f}{K_b}$

$\therefore K = \frac{4 \times 10^2}{2 \times 10^2} = 2$

560 **(6)**

(a), (b), (g), (h) and (k)

a. $CH_3COOH + H_2O \rightarrow H_3O^{\oplus} + CH3COO^{\ominus}$(< *2%*

W_A

b. $\underset{\text{Salt of } W_A}{CH_3COO^{\ominus}} + H_2O \longrightarrow CH_3COOH + \overset{\ominus}{O}H$ (< 2%)

g. $Cl^{\ominus} + H_3O^{\oplus} \rightarrow$ No reaction

h. $Cl^{\ominus} + H_2O \rightarrow$ Noreaction

k. $NH_3 + H_2O \longrightarrow \overset{\oplus}{N}H_4 + \overset{\ominus}{O}H$

n. $K^{\oplus} + \overset{\ominus}{O}H \longrightarrow$ No reaxction

561 **(2)**

Neutral [NaCl and K_2SO_4] and salts of S_A/S_B

564 **(7)**

Salt of W_A/S_B (CH_3COONa) is formed

It we calculate pH by using hydrolysis formula for salt of W_A/W_B

pH $= \frac{1}{2}(pK_w + pK_a + \log C)\Big]$ Salts of S_A

$\left[[\text{Salt}] = \frac{10^{-6}}{2}\left(\begin{matrix}\text{Volume is} \\ \text{doubled}\end{matrix}\right)\right]$

$= \frac{1}{2}\left(14 + 4.7 + \log\frac{10^{-6}}{2}\right)$

$= \frac{1}{2}(18.7 - 6 - 0.3) = 6.2$

But pH of salt of W_A/S_B is always > 7

So for such dilute solutions of CH_3COOH and NaOH. Contribution of $\overset{\ominus}{O}H$ ions from H_2O must be considered

$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$

$10^{-6}\,M \times V \quad 10^{-6} M \times V \quad 10^{-6} M \times V$

$[CH_3COONa] = \frac{10^{-6}\text{M} \times V}{2V} = 0.5 \times 10^{-6}$

$= 5 \times 10^{-7} < 10^{-6}$ M

$[\overset{\ominus}{O}H] = \left(\frac{k_w \times C}{K_a}\right)^{\frac{1}{2}} = \left(\frac{10^{-4} \times 5 \times 10^{-7}}{2 \times 10^{-5}}\right)^{\frac{1}{2}}$

$= (2.5)^{\frac{1}{2}} \times 10^{-8}\text{M} = 1.58 \times 10^{-8}\text{M} < 10^{-6}\text{M}$

Total $[\overset{\ominus}{O}H] = [1.58 \times 10^{-8} + 10^{-7}$ (From H_2O)]

$= 10^{-7}\,(1.58 \times 10^{-1} + 1) = 1.158 \times 10^{-7}$

$pOH = -\log(1.158 \times 10^{-7}) = 6.93$

$pH = 14 - 6.93 = 7.07 \approx 7$

566 **(3,2,1,1)**

a. (3)

Salt of W_A/W_B and W_B/S_A hydrolyses more in water

III. $NaC_2H_3O_2$ (salt of W_A/S_B) $\rightarrow C_2H_3O_2^{\ominus}$

IV. NH_4Cl (salt of W_B/S_A) $\longrightarrow \overset{\oplus}{N}H_4$

V. MgS (salt of W_A/S_B) $\rightarrow S^{2-}$

b. (2)

Salt of S_A/S_B do not hydrolyse

VI. Na_2SO_4 VIII. KCl

c. (1)

Salt of W_A/S_B ($NH_4C_2H_3O_2$) with same value of K_a and K_b, both hydrolyse to the same extent. (K_a of $CH_3COOH = K_b$ of NH_3)

d. (1)

II. Salt of W_A/W_B with different K_a and K_b, both hydrolyse to the same extent. ($PhCOONH_4$ have different K_a and K_b)

578 **(a)**

For $A + B \rightleftharpoons AB$

$$K = \frac{[AB]}{[A][B]}$$

When $2A + 2B \rightleftharpoons 2AB$

$$K = 2AB$$

579 **(5)**

Acidic

$$\left[HClO_4, HCl, HC_2H_3O_2, \frac{(NH_4)_2SO_4 \text{ and } NH_4Cl}{\text{Both salt of } \frac{W_B}{S_A}}\right]$$

(Five compounds)

581 **(d)**

0 At equilibrium $\Delta G = 0$

582 **(a)**

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

When $\Delta n = 0$

$$K_p = K_c$$

583 **(3)**

Basic [$NH_3 + NH_4Cl$ (basic buffer), NH_3, NaOH]

The basic buffer is less basic than NH_3 alone because the $\overset{\oplus}{NH_4}$ suppresses the ionization of NH_3 in the buffer

585 **(54)**

I. HCN is W_A; $pH_{W_A} = \frac{1}{2}(pK_a - \log C)$

$$= \frac{1}{2}(10 - \log 10^{-1}) = 5.5$$

II. Acidic buffer: $pH_{\text{acidic Buffer}} = pK_a + \log\frac{0.1}{0.1} = 5$

III. HCl is S_A: $pH = -\log(0.1) = 1$

IV. NH_4OH is W_B: $pOH_{W_B} = \frac{1}{2}(pK_a - \log C)$

$$= \frac{1}{2}(5 + 1) = 3$$

$pH = 14 - 3 = 11$

V. NaOH is S_B: $pOH = -\log(0.01) = 2$,

$pH = 14 - 2 = 12$

VI: Salt of W_A/W_B: $pH = 7$

$\therefore$ Magic number $= 5.5 \times 2 + 5 \times 1 + 1 \times 3 + 11 \times 2 + 12 \times 0.5 + 7 \times 1 = 54$

587 **(a)**

At equilibrium $\Delta G = 0$

$$\Delta G = -nRT \ln K$$

$$0 = -nRT \ln K$$

Or $K = 1$

590 **(4)**

II A group: Pb^{2+}, Cu^{2+}

III group: Cr^{3+}

IV group: Zn^{2+}

591 **(b)**

For $A + B \rightleftharpoons AB$; $K = 0.5$

For $AB \rightleftharpoons A + B$; $K' = ?$

$$\therefore K' = \frac{1}{K} = \frac{1}{0.5} = 2$$

592 **(a)**

$$C_2H_5OH + CH_3COOH \rightleftharpoons CH_3COOC_2H_5 + H_2O$$

Initial 1 1 0 0

At equ. $1 - \frac{1}{2}$ $1 - \frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$

$$K = \frac{[CH_3COOC_2H_5][H_2O]}{[C_2H_5OH][CH_3COOH]} = \frac{\frac{1}{2} \times \frac{1}{2}}{\frac{1}{2} \times \frac{1}{2}} = 1$$