DPP - Daily Practice Problems

Chapter-wise Sheets

Date : ☐ **Start Time :** ☐ **End Time :** ☐

CHEMISTRY (CC07)

SYLLABUS : Equilibrium

Max. Marks : 180 **Marking Scheme :** + 4 for correct & (–1) for incorrect **Time : 60 min.**

INSTRUCTIONS : This Daily Practice Problem Sheet contains 45 MCQ's. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.

1. If 1.0 mole of I_2 is introduced into 1.0 litre flask at 1000 K, at quilibrium ($K_c = 10^{-6}$), which one is correct?

(a) $[I_2(g)] > [I^-(g)]$ (b) $[I_2(g)] < [I^-(g)]$

(c) $[I_2(g)] = [I^-(g)]$ (d) $[I_2(g)] = \frac{1}{2}[I^-(g)]$

2. In a reaction, $A + 2B \rightleftharpoons 2C$, 2.0 mole of 'A', 3.0 mole of 'B' and 2.0 mole of 'C' are placed in a 2.0 L flask and the equilibrium concentration of 'C' is 0.5 mol/L. The equilibrium constant (K) for the reaction is

(a) 0.073 (b) 0.147

(c) 0.05 (d) 0.026

3. K_c for the reaction

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

at 300 K is 4.0×10^{-6}. K_p for the above reaction will be ($R = 2\ \text{cal mol}^{-1}\text{K}^{-1}$)

(a) 2.4×10^{-3} (b) 4×10^{-6}

(c) $4 \times 10^{-6}(RT)^2$ (d) 16×10^{-12}

4. $\Delta G°$ for the reaction $X + Y \rightleftharpoons Z$ is –4.606 kcal. The equilibrium constant for the reaction at 227°C is

(a) 100 (b) 10 (c) 2 (d) 0.01

5. The equilibrium constant for the reaction

$$SO_3(g) \rightleftharpoons SO_2(g) + \frac{1}{2}O_2(g)$$

is $K_c = 4.9 \times 10^{-2}$. The value of K_c for the reaction

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

will be

(a) 9.8×10^{-2} (b) 4.9×10^{-2}

(c) 416 (d) 2.40×10^{-3}

6. Four species are listed below:

i. HCO_3^- ii. H_3O^+ iii. HSO_4^- iv. HSO_3F

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

(a) iv < ii < iii < i (b) ii < iii < i < iv

(c) i < iii < ii < iv (d) iii < i < iv < ii

RESPONSE GRID

1. ⓐⓑⓒⓓ 2. ⓐⓑⓒⓓ 3. ⓐⓑⓒⓓ 4. ⓐⓑⓒⓓ 5. ⓐⓑⓒⓓ
6. ⓐⓑⓒⓓ

Space for Rough Work

7. The degree of dissociation of dinitrogen tetroxide $N_2O_4\ (g) \longrightarrow 2NO_2(g)$ at temperature T and total pressure P is α. Which one of the following is the correct expression for the equilibrium constant (K_p) at this temperature?

(a) $\dfrac{2\alpha}{(1-\alpha^2)}$ (b) $\dfrac{\alpha^2 P}{1-\alpha}$

(c) $\dfrac{4\alpha^2}{(1-\alpha^2)}$ (d) $\dfrac{4\alpha^2 P}{(1-\alpha^2)}$

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

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

9. The dissociation of a gas AB_2 at equilibrium can be represented as :

$$2AB_2(g) \rightleftharpoons 2AB(g) + B_2(g)$$

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

(a) $(2K_p/P)$ (b) $(2K_p/P)^{1/3}$

(c) $(2K_p/P)^{1/2}$ (d) (K_p/P)

10. The exothermic formation of ClF_3 is represented by the equation :

$$Cl_2(g) + 3F_2(g) \rightleftharpoons 2ClF_3(g)\ ;\ \Delta H = -329\,kJ$$

Which of the following will increase the quantity of ClF_3 in an equilibrium mixture of Cl_2, F_2 and ClF_3?

(a) Adding F_2

(b) Increasing the volume of the container

(c) Removing Cl_2

(d) Increasing the temperature

11. Match the columns

	Column-I		**Column-II**
A.	$Q_c < K_c$,	I.	Net reaction goes from right to left.
B.	$Q_c > K_c$,	II.	Net reaction goes from left to right.
C.	$Q_c = K_c$,	III.	No net reaction occurs.

(a) A – I; B – II; C – III (b) A – III; B – II; C – I

(c) A – I; B – III; C – II (d) A – II; B – I; C – III

12. Which of the following statement(s) is/are correct ?

(i) ΔG is negative, then the reaction is spontaneous and proceeds in the forward direction.

(ii) ΔG is positive, then reaction is non-spontaneous

(iii) ΔG is 0, then reaction is at equilibrium

(a) (i), (ii) and (iii) are correct

(b) (i) and (ii)

(c) (ii) and (iii) are correct

(d) only (iii) is correct

13. On the basis of Le Chatelier's principle, predict which of the following conditions would be unfavourable for the formation of SO_3? Given that

$$2SO_2 + O_2 \rightleftharpoons 2SO_3;\ \Delta H = -42\ kcal$$

(a) Low pressure and low temperature

(b) High pressure and low temperature

(c) High temperature and low pressure

(d) High concentration of SO_2

14. The standard Gibbs energy change at 300 K for the reaction $2A \rightleftharpoons B + C$ is 2494.2 J. At a given time, the composition of the reaction mixture is $[A] = \frac{1}{2}$, $[B] = 2$ and $[C] = \frac{1}{2}$. The reaction proceeds in the : [$R = 8.314$ J/K/mol, $e = 2.718$]

(a) forward direction because $Q < K_c$

(b) reverse direction because $Q < K_c$

(c) forward direction because $Q > K_c$

(d) reverse direction because $Q > K_c$

15. If the equilibrium constant for $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ is K, the equilibrium constant for

$$\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons NO(g) \text{ will be:}$$

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

(c) K (d) K^2

16. The following reaction is performed at 298 K.

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

The standard free energy of formation of NO(g) is 86.6 kJ/mol at 298 K. What is the standard free energy of formation of $NO_2(g)$ at 298 K? ($K_p = 1.6 \times 10^{12}$)

(a) $86600 - \dfrac{\ln(1.6 \times 10^{12})}{R\ (298)}$

(b) $0.5[2 \times 86{,}600 - R(298)\ln(1.6 \times 10^{12})]$

(c) $R(298)\ln(1.6 \times 10^{12}) - 86600$

(d) $86600 + R(298)\ln(1.6 \times 10^{12})$

17. Which of the following pairs constitutes a buffer?

(a) NaOH and NaCl (b) HNO_3 and NH_4NO_3

(c) HCl and KCl (d) HNO_2 and $NaNO_2$

RESPONSE GRID	
	7. ⓐⓑⓒⓓ 8. ⓐⓑⓒⓓ 9. ⓐⓑⓒⓓ 10. ⓐⓑⓒⓓ 11. ⓐⓑⓒⓓ 12. ⓐⓑⓒⓓ 13. ⓐⓑⓒⓓ 14. ⓐⓑⓒⓓ 15. ⓐⓑⓒⓓ 16. ⓐⓑⓒⓓ 17. ⓐⓑⓒⓓ

18. For dibasic acid correct order is

(a) $K_{a_1} < K_{a_2}$ (b) $K_{a_1} > K_{a_2}$

(c) $K_{a_1} = K_{a_2}$ (d) not certain

19. Consider the expression $\Delta G = -RT\ln K_p + RT\ln Q_p$ and select the correct statement at equilibrium

(a) $\Delta G = 0, Q_p > K_p$ the equilibrium reaction will shift from left to right

(b) $\Delta G = 0, Q_p = K_p$ the equilibrium reaction will shift from left to right

(c) $\Delta G = \infty, Q_p < K_p$ the equilibrium reaction will shift from right to left

(d) $\Delta G < 0, Q_p > K_p$ the equilibrium reaction will shift from right to left

where Q_p and K_p term refer to reaction quotient and equilibrium constant at constant pressure respectively.

20. K_c for $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ is 0.04 at 250°C. How many moles of PCl_5 must be added to a 3 L flask to obtain a Cl_2 concentration of 0.15 M

(a) 4.2 moles (b) 2.1 moles

(c) 5.5 moles (d) 6.3 moles

21. In the following hypothetical reaction

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

initial moles of A are twice that of B. If at equilibrium moles of B and C are equal. Percentage of B reacted is

(a) 60% (b) 40% (c) 10% (d) 20%

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

(a) Na_2CO_3 (b) OH^-

(c) HCO_3^- (d) NH_3

23. Match the columns :

	Column-I		Column-II
A.	$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ (t = 300°C)	I.	$\Delta n > 0$
B.	$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ (t = 50°C)	II.	$K_P < K_C$
C.	$C(s) + H_2O(g) \rightleftharpoons$	III.	K_P not defined $CO(g) + H_2(g)$
D.	$CH_3COOH(l) + C_2H_5OH(l) \rightleftharpoons CH_3COOC_2H_5(l) + H_2O(l)$	IV.	$\Delta n = 1$

(a) A – II; B – I; C – IV; D – III

(b) A – I; B – II; C – III; D – IV

(c) A – III; B – I; C – IV; D – II

(d) A – IV; B – II; C – I; D – III

24. Which of the following statements are correct ?

(i) Ionic product of water $(K_w) = [H^+][OH^-] = 10^{-14} M^2$

(ii) At 298K $[H^+] = [OH^-] = 10^{-7}$

(iii) K_w does not depend upon temperature

(iv) Molarity of pure water = 55.55M

(a) (i), (ii) and (iii) (b) (i), (ii) and (iv)

(c) (i) and (iv) (d) (ii) and (iii)

25. At a certain temperature the dissociation constants of formic acid and acetic acid are 1.8×10^{-4} and 1.8×10^{-6} respectively. The concentration of acetic acid solution in which the hydrogen ion has the same concentration as in 0.001 M formic acid solution is equal to

(a) 0.001 M (b) 0.01 M

(c) 0.1 M (d) 0.0001 M

26. The first and second dissociation constants of an acid H_2A are 1.0×10^{-5} and 5.0×10^{-10} respectively. The overall dissociation constant of the acid will be

(a) 0.2×10^5 (b) 5.0×10^{-5}

(c) 5.0×10^{15} (d) 5.0×10^{-15}.

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

(a) 1.11×10^{-4} M (b) 3.7×10^{-4} M

(c) 3.7×10^{-3} M (d) 1.11×10^{-3} M

28. The solubility product of AgCl is 4.0×10^{-10} at 298 K. The solubility of AgCl in 0.04 M $CaCl_2$ will be

(a) 2.0×10^{-5} M (b) 1.0×10^{-4} M

(c) 5.0×10^{-9} M (d) 2.2×10^{-4} M

29. The pH of a buffer containing equal molar concentrations of a weak base and its chloride (K_b for weak base $= 2 \times 10^{-5}$, log 2 = 0.3) is

(a) 5 (b) 9

(c) 4.7 (d) 9.3

30. In a saturated solution of the sparingly soluble strong electrolyte $AgIO_3$ (molecular mass = 283) the equilibrium which sets is $AgIO_3(s) \rightleftharpoons Ag^+(aq) + IO_3^-(aq)$. If the solubility product constant K_{sp} of $AgIO_3$ at a given temperature is 1.0×10^{-8}, what is the mass of $AgIO_3$ contained in 100 ml of its saturated solution?

(a) 1.0×10^{-4} g (b) 28.3×10^{-2} g

(c) 2.83×10^{-3} g (d) 1.0×10^{-7} g.

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

(a) 3.5×10^{-4} (b) 1.1×10^{-5}

(c) 1.8×10^{-5} (d) 9.0×10^{-6}

RESPONSE GRID

18. ⓐⓑⓒⓓ 19 ⓐⓑⓒⓓ 20. ⓐⓑⓒⓓ 21. ⓐⓑⓒⓓ 22. ⓐⓑⓒⓓ
23. ⓐⓑⓒⓓ 24. ⓐⓑⓒⓓ 25. ⓐⓑⓒⓓ 26. ⓐⓑⓒⓓ 27. ⓐⓑⓒⓓ
28. ⓐⓑⓒⓓ 29. ⓐⓑⓒⓓ 30. ⓐⓑⓒⓓ 31. ⓐⓑⓒⓓ

32. The K_{sp} for $Cr(OH)_3$ is 1.6×10^{-30}. The solubility of this compound in water is :

(a) $\sqrt[4]{1.6\times10^{-30}}$ (b) $\sqrt[4]{1.6\times10^{-30}/27}$

(c) $1.6\times10^{-30/27}$ (d) $\sqrt{1.6\times10^{-30}}$

33. For the reaction $CO\,(g)+(1/2)\,O_2\,(g)=CO_2\,(g)$, K_p/K_c is

(a) RT (b) $(RT)^{-1}$

(c) $(RT)^{-1/2}$ (d) $(RT)^{1/2}$

34. For the reaction : $2NO_{2(g)} \rightleftharpoons 2NO_{(g)} + O_{2(g)}$,

($K_c = 1.8\times10^{-6}$ at 184°C) ($R=0.0831$ kJ/(mol. K))

When K_p and K_c are compared at 184°C, it is found that

(a) Whether K_p is greater than, less than or equal to K_c depends upon the total gas pressure

(b) $K_p = K_c$

(c) K_p is less than K_c

(d) K_p is greater than K_c

35. A monobasic weak acid solution has a molarity of 0.005 and pH of 5. What is the percentage ionization in this solution?

(a) 2.0 (b) 0.2 (c) 0.5 (d) 0.25

36. Values of dissociation constant, K_a are given as follows :

Acid	K_a
HCN	6.2×10^{-10}
HF	6.6×10^{-4}
HNO_2	7.2×10^{-4}

Correct order of increasing base strength of the base CN^-, F^- and NO_2^- will be :

(a) $F^- < CN^- < NO_2^-$ (b) $NO_2^- < CN^- < F^-$

(c) $F^- < NO_2^- < CN^-$ (d) $NO_2^- < F^- < CN^-$

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

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

38. The pH of aqueous solution of 1M $HCOONH_4$, pK_a of HCOOH is 3.8 and pK_b of NH_3 is 4.8

(a) 6.5 (b) 4.8

(c) 3.8 (d) 8.6

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

(a) 5.1×10^{-5}M (b) 8.1×10^{-8}M

(c) 8.1×10^{-7}M (d) 4.1×10^{-5}M

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

(a) 1.2×10^{-10} g (b) 1.2×10^{-9} g

(c) 6.2×10^{-5} g (d) 5.0×10^{-8} g

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

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

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

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

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

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

(c) (iii) only (d) (i) only

42. Which solution has pH equal to 10 ?

(a) 10^{-4} M KOH (b) 10^{-10} M KOH

(c) 10^{-10} M HCl (d) 10^{-4} M HCl

43. Calculate the pH of 0.5 M aqueous solution of NaCN, the pK_b of CN^- is 4.70

(a) 4.70 (b) 11.5 (c) 7 (d) 6.5

44. For the following three reactions a, b and c, equilibrium constants are given:

(i) $CO(g)\cdot H_2O(g) \rightleftharpoons CO_2(g)\cdot H_2(g); K_1$

(ii) $CH_4(g)\cdot H_2O(g) \rightleftharpoons CO(g)\cdot 3H_2(g); K_2$

(iii) $CH_4(g)+2H_2O(g) \rightleftharpoons CO_2(g)+4H_2(g); K_3$

(a) $K_1\sqrt{K_2} = K_3$ (b) $K_2K_3 = K_1$

(c) $K_3 = K_1K_2$ (d) $K_3.K_2^3 = K_1^2$

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

(a) 1.8 atm (b) 3 atm

(c) 0.3atm (d) 0.18atm

RESPONSE GRID	**32.** ⓐⓑⓒⓓ	**33.** ⓐⓑⓒⓓ	**34.** ⓐⓑⓒⓓ	**35.** ⓐⓑⓒⓓ	**36.** ⓐⓑⓒⓓ
	37. ⓐⓑⓒⓓ	**38.** ⓐⓑⓒⓓ	**39.** ⓐⓑⓒⓓ	**40.** ⓐⓑⓒⓓ	**41.** ⓐⓑⓒⓓ
	42. ⓐⓑⓒⓓ	**43.** ⓐⓑⓒⓓ	**44.** ⓐⓑⓒⓓ	**45.** ⓐⓑⓒⓓ	

Space for Rough Work

1. **(a)** $I_2 \rightleftharpoons 2I^-$

$1-x \quad\quad 2x$

$$K_c = \frac{(2x)^2}{(1-x)} = 10^{-6}$$

Soln. shows that $(1-x) > 2x \ \therefore \left[I_2(g)\right] > \left[I^-(g)\right]$

2. **(c)**

	A	$+ 2B$	$\rightleftharpoons 2C$
Initial moles in 2 litres	2	3	2
At Equilibrium moles in 2 litres	2.5	4	1
Molar conc. moles in 2 litres	1.25	2	0.5

$$K_c = \frac{(0.5)^2}{(1.25)(2)^2} = 0.05$$

3. **(b)** $K_p = K_c(RT)^{\Delta n}$ since $\Delta n = 0$, $K_p = K_c$.

4. **(a)** $\Delta G^o = -2.303\, RT \log K$

$-4.606 \times 10^3 = -2.303 \times 2 \times 500 \log K_c$

$\therefore K_c = 100.$

5. **(c)** $SO_3(g) \rightleftharpoons SO_2(g) + \frac{1}{2}O_2(g)$

$$K_c = \frac{[SO_2][O_2]^{1/2}}{[SO_3]} = 4.9 \times 10^{-2};$$

On taking the square of the above reaction

$$\frac{[SO_2]^2[O_2]}{[SO_3]^2} = 24.01 \times 10^{-4}$$

now K'_c for $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3$

$$= \frac{[SO_3]^2}{[SO_2]^2[O_2]} = \frac{1}{24.01 \times 10^{-4}} = 416$$

6. **(c)** The correct order of acidic strength of the given species is

$$\underset{(iv)}{HSO_3F} > \underset{(ii)}{H_3O^+} > \underset{(iii)}{HSO_4^-} > \underset{(i)}{HCO_3^-}$$

or (i) < (iii) < (ii) < (iv)

It corresponds to choice (c) which is correct answer.

7. **(d)** $N_2O_4 \rightleftharpoons 2NO_2$

$1-\alpha \quad\quad 2\alpha$

Total moles at equ $= 1 - \alpha + 2\alpha = 1 + \alpha$

$$K_c = \frac{p^2_{NO_2}}{p_{N_2O_4}} = \frac{\left(\frac{2\alpha}{1+\alpha}.P\right)^2}{\frac{1-\alpha}{1+\alpha}.P} = \frac{4\alpha^2 P}{1-\alpha^2}$$

8. **(b)** Let the initial moles of X be ‘a’ and that of Z be ‘b’ then for the given reactions, we have

	X	$\rightleftharpoons 2Y$
Initial a moles		0
At equi (moles)	$a(1-\alpha)$	$2a\alpha$

Total no. of moles $= a(1-\alpha) + 2a\alpha$

$= a - a\alpha + 2a\alpha$

$= a(1+\alpha)$

Now, $$K_{P_1} = \frac{(n_Y)^2}{n_X} \times \left(\frac{P_{T_1}}{\Sigma n}\right)^{\Delta n}$$

$$K_{P_1} = \frac{(2a\alpha)^2.P_{T_1}}{[a(1-\alpha)][a(1+\alpha)]}$$

	Z	$\rightleftharpoons P$	$+ Q$
Initial b moles		0	0
At equi (moles)	$b(1-\alpha)$	$b\alpha$	$b\alpha$

Total no. of moles $= b(1-\alpha) + b\alpha + b\alpha$

$= b - b\alpha + b\alpha + b\alpha$

$= b(1+\alpha)$

Now $$K_{P_2} = \frac{n_Q \times n_P}{n_Z} \times \left[\frac{P_{T_2}}{\Sigma_n}\right]^{\Delta_n}$$

or $$K_{P_2} = \frac{(b\alpha)(b\alpha).P_{T_2}}{[b(1-\alpha)][b(1+\alpha)]}$$

or $$\frac{K_{P_1}}{K_{P_2}} = \frac{4\alpha^2.P_{T_1}}{(1-\alpha^2)} \times \frac{(1-\alpha)^2}{P_{T_2}.\alpha^2} = \frac{4P_{T_1}}{P_{T_2}}$$

or $$\frac{P_{T_1}}{P_{T_2}} = \frac{1}{9} \qquad \left[\text{given: } \frac{K_{P_1}}{K_{P_2}} = \frac{1}{9}\right]$$

or $$\frac{P_{T_1}}{P_{T_2}} = \frac{1}{36} \text{ or } 1:36$$

i.e., (b) is the correct answer.

9. **(b)** For the reaction

$$2AB_2(g) \rightleftharpoons 2AB(g) + B_2(g)$$

at equi $\quad 2(1-x) \quad\quad 2x \quad\quad x$

$$K_c = \frac{[AB]^2[B_2]}{[AB_2]^2} \text{ or } K_c = \frac{(2x)^2 \times x}{\{2(1-x)\}^2}$$

$= x^3$ [$(1-x)$ can be neglected in denominator $(1-x) \simeq 1$]

The partial pressure at equilibrium are calculated on the basis of total number of moles at equilibrium.

Total number of moles

$= 2(1-x) + 2x + x = (2+x)$

$\therefore\ P_{AB_2} = \frac{2(1-x)}{(2+x)} \times P$, where P is the total pressure.

$$P_{AB} = \frac{2x}{(2+x)} \times P,\ P_{B_2} = \frac{x}{(2+x)} \times P$$

Since x is very small so can be neglected in denominator thus, we get

$P_{AB_2} = (1-x) \times P \qquad P_{AB} = x \times P$

$$P_{B_2} = \frac{x}{2} \times P$$

$$\text{Now, } K_p = \frac{(P_{AB})^2(P_{B_2})}{(P_{AB_2})^2}$$

$$= \frac{(x)^2 \times P^2 . P \times \frac{x}{2}}{(1-x)^2 \times P^2}$$

$$= \frac{x^3 . P^3}{2 \times 1 \times P^2} \quad [\therefore 1 - x \simeq 1]$$

$$= \frac{x^3 . P}{2} \text{ or } x^3 = \frac{2.K_p}{P} \text{ or } x = \left(\frac{2K_p}{P}\right)^{\frac{1}{3}}$$

10. (a) The reaction given is an exothermic reaction thus according to Le Chatelier's principle lowering of temperature, addition of F_2 and Cl_2 favour the forward direction and hence the production of ClF_3.

11. (d)

12. (a)

13. (c) Since reaction is exothermic hence low temperature will favour forward reaction also volume is decreased by applying high pressure.

14. (d) $\Delta G° = 2494.2J$

$2A \rightleftharpoons B + C.$

$R = 8.314$ J/K/mol.

$e = 2.718$

$$[A] = \frac{1}{2}, [B] = 2, [C] = \frac{1}{2}$$

$$Q = \frac{[B][C]}{[A]^2} = \frac{2 \times 1/2}{\left(\frac{1}{2}\right)^2} = 4$$

$\Delta G° = -2.303\ RT \log K_c$

$2494.2 J = -2.303 \times (8.314 \text{ J/K/mol}) \times (300K) \log K_c$

$$\Rightarrow \quad \log K_c = -\frac{2494.2 \text{ J}}{2.303 \times 8.314 \text{ J/K/mol} \times 300K}$$

$\Rightarrow \quad \log K_c = -0.4341$

$K_c = 0.37$

$Q > K_c$

15. (a) $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$

$$K \bullet \frac{[NO]^2}{[N_2][O_2]}$$

$$\frac{1}{2}N_2 \bullet \frac{1}{2}O_2 \rightleftharpoons NO$$

$$K \bullet \bullet \frac{[NO]}{[N_2]^{1/2}[O_2]^{1/2}} \bullet K^{1/2}$$

16. (b) $\Delta G°_{NO(g)} = 86.6k$ J/mol $= 86600$ J/mol

$G°_{N\bullet_2(g)} = x$ J/mol

$T = 298, K_p = 1.6 \times 10^{12}$

$\Delta G° \quad = \qquad -RT \ln K_p$

Given equation,

$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$

$\therefore \quad 2\Delta G°_{NO2} - 2\Delta G^{\bullet}_{NO} = -R(298) \ln(1.6 \times 10^{12})$

$2\Delta G°_{NO2} - 2 \times 86600 = -R(298) \ln(1.6 \times 10^{12})$

$2\Delta G°_{NO2} = 2 \times 86600 - R(298) \ln(1.6 \times 10^{12})$

$$\Delta G°_{NO2} = \frac{1}{2}[2 \times 86600 - R(298) \ln(1.6 \times 10^{12}]$$

$= 0.5 [2 \times 86600 - R(298) \ln(1.6 \times 10^{12})]$

17. (d) HNO_2 is a weak acid and $NaNO_2$ is salt of that weak acid and strong base (NaOH).

18. (b) In dibasic acids the loss of second proton occurs much less readily than the first. Usually the K_a values for successive loss of protons from these acids differ by at least a factor of 10^{-3} i.e., $K_{a_1} > K_{a_2}$

$$H_2X \rightleftharpoons H^{\bullet} \bullet HX^{\bullet} \bullet K_{a_1} \bullet$$

$$HX^{\bullet} \rightleftharpoons H^{\bullet} \bullet X^{2\bullet} \bullet K_{a_2} \bullet$$

19. (b) Van't Hoff reaction isotherm is $\Delta G = \Delta G° + RT \ln Qp$

When the reaction is in a state of equilibrium $\Delta G = 0$

Then $\Delta G° = -RT \ln Q_p = -RT \ln K_p$

20. (b) At equilibrium the moles of Cl_2 must be $= 0.15 \times 3 = 0.45$

$$PCl_5 \rightleftharpoons PCl_3 + Cl_2$$

$$\frac{x - 0.45}{3} \qquad \frac{0.45}{3} \qquad \frac{0.45}{3} \quad \text{Eqb.Conc.}$$

$$K_c = \frac{[PCl_3][Cl_2]}{[PCl_5]}$$

$\therefore 0.04 = \dfrac{0.15 \times 0.15}{(x-0.45)/3}$ $\qquad \therefore x = 2.1$ moles

21. **(a)** $A + 3B \rightleftharpoons 2C + D$

$\begin{array}{cccc} 2a & a & 0 & 0 \\ 2a-x & a-3x & 2x & x \end{array}$

$a - 3x = 2x$ (condition given)

$\therefore x = \dfrac{a}{5}$

The % of B reacted is

$\dfrac{3x}{a} \times 100 = \dfrac{3}{a} \cdot \dfrac{a}{5} \times 100 = 60\%$

22. **(c)** $H_2CO_3 \rightleftharpoons \overset{+}{H} + \overset{-}{HCO_3} \rightleftharpoons \overset{+}{H} + \overset{-}{CO_3}$

HCO_3^- can donate and accept H^+.

23. **(a)** (A) $K_P = K_C (RT)^{\Delta n}$

$\dfrac{K_P}{K_C} = (RT)^{\Delta n}$ as $\Delta n = -ve \Rightarrow K_P < K_C$

(B) $\Delta n > 0$

(C) $\Delta n = 2 - 1 = 1$

(D) As the reaction is not containing any gaseous component therefore K_P is not defined for this.

24. **(c)** K_w depends upon temperature as it is an equilibrium constant.

25. **(b)** $[H^+] = \sqrt{C \times K_a} = \sqrt{0.001 \times 1.8 \times 10^{-4}}$ for formic acid

$[H^+] = \sqrt{C_2 \times 1.8 \times 10^{-5}}$ for acetic acid Equating and solving for $C_2 = 0.01$ M.

26. **(d)** $H_2A \rightleftharpoons H^{\bullet} \bullet HA^{\bullet}$

$\therefore K_1 = 1.0 \times 10^{-5} = \dfrac{[H^+][HA^-]}{[H_2A]}$ (Given)

$HA^- \longrightarrow H^+ + A^{--}$

$\therefore K_2 = 5.0 \times 10^{-10} = \dfrac{[H^+][A^{--}]}{[HA^-]}$ (Given)

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

$= (1.0 \times 10^{-5}) \times (5 \times 10^{-10}) = 5 \times 10^{-15}$

27. **(b)** $[H_3O]^+$ for a solution having pH = 3 is given by

$[H_3O]^+ = 1 \times 10^{-3}$ moles/litre

$[\therefore [H_3O]^+ = 10^{-pH}]$

Similarly for solution having pH = 4,

$[H_3O]^+ = 1 \times 10^{-4}$ moles/ litre and for pH = 5

$[H_3O^+] = 1 \times 10^{-5}$ moles/ litre

Let the volume of each solution in mixture be 1L, then total volume of mixture solution $L = (1 + 1 + 1)$ L = 3L

Total $[H_3O]^+$ ion present in mixture solution $= (10^{-3} + 10^{-4} + 10^{-5})$ moles

Then $[H_3O]^+$ ion concentration of mixture solution

$= \dfrac{10^{-3} + 10^{-4} + 10^{-5}}{3} M = \dfrac{0.00111}{3} M$

$= 0.00037 M = 3.7 \times 10^{-4} M.$

28. **(c)** Solubility of AgCl

$[Ag^+] = \dfrac{K_{sp}}{[Cl^-]} = \dfrac{4 \times 10^{-10}}{0.08} = 5.0 \times 10^{-9} M$

[0.08 M is concentration of $[Cl^-]$ from $CaCl_2$]

29. **(d)** $pOH = -\log K_b + \log \dfrac{[SALT]}{[BASE]}$

$= -\log K_b \left(\text{since} \dfrac{SALT}{BASE} = 1\right)$

$= -\log 2 \times 10^{-5} = 4.7$

$pH + pOH = 14$

$\therefore pH = 9.3$

30. **(c)** Let s = solubility

$AgIO_3 \rightleftharpoons \underset{s}{Ag^{\bullet}} \bullet \underset{s}{IO_3^{\bullet}}$

$K_{sp} = [Ag^+][IO_3^-] = s \times s = s^2$

Given $K_{sp} = 1 \times 10^{-8}$

$\therefore \quad s = \sqrt{K_{sp}} = \sqrt{1 \times 10^{-8}}$

$= 1.0 \times 10^{-4}$ mol/lit $= 1.0 \times 10^{-4} \times 283$ g/lit

$(\because \text{Molecular mass of } AgIO_3 = 283)$

$= \dfrac{1.0 \times 10^{-4} \times 283 \times 100}{1000}$ gm / 100ml

$= 2.83 \times 10^{-3}$ gm/ 100ml

31. **(d)** $pH = pK_a + \log\left[\dfrac{Salt}{Acid}\right]$

$\log\left[H^+\right] = \log K_a - \log\left[\dfrac{Salt}{Acid}\right]$

$\log\left[H^+\right] = \log K_a + \log\left[\dfrac{Acid}{Salt}\right]$

$\left[H^+\right] = K_a\left[\dfrac{Acid}{Salt}\right]$

$= 1.8 \times 10^{-5} \times \dfrac{0.1}{0.2} = 9 \times 10^{-6}$

32. **(b)** $Cr(OH)_3(s) \rightleftharpoons \underset{s}{Cr^{3+}(aq.)} + \underset{3s}{3OH^-(aq.)}$

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

$27S^4 = K_{sp}$

$s = \left(\dfrac{K_{sp}}{27}\right)^{1/4} = \left(\dfrac{1.6 \times 10^{-30}}{27}\right)^{1/4}$

33. **(c)** $K_p = K_c(RT)^{\Delta n}$;

$$\Delta n = 1 - \left(1 + \frac{1}{2}\right) = 1 - \frac{3}{2} = -\frac{1}{2}. \therefore \frac{K_p}{K_c} = (RT)^{-1/2}$$

34. **(d)** For the reaction:- $2NO_2(g) \rightleftharpoons 2NO(g) + O_2(g)$

Given $K_c = 1.8 \times 10^{-6}$ at 184 °C

$R = 0.0831$ Kj/mol. K

$K_p = 1.8 \times 10^{-6} \times 0.0831 \times 457 = 6.836 \times 10^{-6}$

[$\because$ 184°C = (273 + 184) = 457k, $\Delta n = (2+1, -1) = 1$]

Hence it is clear that $K_p > K_c$

35. **(b)** $HA \longrightarrow H^+ + A^-$

$$K_a = \frac{[H^+][A^-]}{[HA]}, \quad \because [H^+] = 10^{-pH}$$

$\therefore$ $[H^+] = 10^{-5}$; and at equilibrium $[H^+] = [A^-]$

$$\therefore K_a = \frac{10^{-5} \times 10^{-5}}{0.0015} = 2 \times 10^{-8}$$

$$\alpha = \sqrt{\frac{K_a}{C}} = \sqrt{\frac{2 \times 10^{-8}}{.005}} = \sqrt{4 \times 10^{-6}} = 2 \times 10^{-3}$$

Percentage ionization = 0.2

36. **(c)** Higher the value of K_a lower will be the value of pK_a i.e. higher will be the acidic nature. Further since CN^-, F^- and NO_2^- are conjugate base of the acids HCN, HF and HNO_2 respectively hence the correct order of base strength will be

$F^- < NO_2^- < CN^-$

($\because$ stronger the acid weaker will be its conjugate base)

37. **(d)** $\because$ pH = 1 ; $H^+ = 10^{-1} = 0.1$ M

pH = 2 ; $H^+ = 10^{-2} = 0.01$ M

$\therefore M_1 = 0.1 \quad V_1 = 1$

$M_2 = 0.01 \quad V_2 = ?$

From

$M_1V_1 = M_2V_2$

$0.1 \times 1 = 0.01 \times V_2$

$V_2 = 10$ litres

$\therefore$ Volume of water added = 10 – 1 = 9 litres

38. **(a)** $HCOONH_4$ is a salt of weak acid and weak base ;

$pH = ½\, pK_w + ½\, pK_a - ½\, pK_b$

$$\therefore pH = \frac{1}{2} \times 14 + \frac{1}{2} \times 3.8 - \frac{1}{2} \times 4.8 \text{ ; } pH = 6.5$$

39. **(a)** $\underset{1 \times 10^{-4} M}{Na_2CO_3} \longrightarrow \underset{1 \times 10^{-4} M}{2Na^+} + \underset{1 \times 10^{-4} M}{CO_3^{2-}}$

$K_{SP(BaCO_3)} = [Ba^{2+}][CO_3^{2-}]$

$$[Ba^{2+}] = \frac{5.1 \times 10^{-9}}{1 \times 10^{-4}} = 5.1 \times 10^{-5} M$$

40. **(b)** $AgBr \rightleftharpoons Ag^{\bullet} \bullet Br^{\bullet}$

$K_{sp} = [Ag^+][Br^-]$

For precipitation to occur

Ionic product > Solubility product

$$[Br^{\bullet}] \bullet \frac{K_{sp}}{[Ag^{\bullet}]} \bullet \frac{5 \bullet 10^{\bullet 13}}{0.05} \bullet 10^{\bullet 11}$$

i.e., precipitation just starts when 10^{-11} moles of KBr is added to 1 *l* $AgNO_3$ solution

$\therefore$ Number of moles of Br^- needed from KBr = 10^{-11}

$\therefore$ Mass of KBr = $10^{-11} \times 120 = 1.2 \times 10^{-9}$ g

41. **(a)** (i) $\underset{acid_1}{H_3PO_4} + \underset{base_2}{H_2O_4} \longrightarrow \underset{acid_2}{H_3O^+} + \underset{base_1}{H_2PO_4^-}$

(ii) $\underset{acid_1}{H_2PO_4^-} + \underset{base_2}{H_2O} \dashrightarrow \underset{base_1}{HPO_4^{2-}} + \underset{acid_2}{H_3O^+}$

(iii) $\underset{base_1}{H_2PO_4^-} + \underset{acid_2}{OH^-} \longrightarrow \underset{acid_1}{H_3PO_4} + \underset{base_2}{O^{2-}}$

Hence only in (ii) reaction $H_2PO_4^-$ is acting as an acid.

42. **(a)** $pOH = -\log[OH^-]$

$pH + pOH = 14$

For 10^{-4} KOH, $[OH^-] = 10^{-4}$

$pOH = -\log[OH^-] = -\log 10^{-4} = 4$

$pH = 14 - pOH = 10$

43. **(b)** NaCN is a salt of strong base and weak acid ; pH

$$= 7 + \frac{1}{2}pK_a + \frac{1}{2}\log C$$

pK_a for HCN = 14 - 4.70 = 9.30

$$\therefore pH = 7 + \frac{1}{2} \times 9.30 + \frac{1}{2}\log 0.5; pH = 11.5$$

44. **(c)** Reaction (c) can be obtained by adding reactions (a) and (b) therefore $K_3 = K_1 . K_2$

Hence (c) is the correct answer.

45. **(a)** $CO_2 + C_{(graphite)} \rightleftharpoons 2CO$

$P_{initial}$ 0.5atm $\bullet$

P_{final} (0.5 – x)atm 2x atm

Total P at equilibrium = 0.5 – x + 2x = 0.5 + x atm

$0.8 = 0.5 + x$

$\therefore x = 0.8 - 0.5 = 0.3$ atm

Now $k_p = (P_{C\bullet})^2 / P_{C\bullet_2}$

$$= \frac{(2 \times 0.3)^2}{(0.5 - 0.3)} = \frac{(0.6)^2}{(0.2)} = 1.8 \text{ atm}$$