

# 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.

- If 1.0 mole of  $I_2$  is introduced into 1.0 litre flask at 1000 K, at equilibrium ( $K_c = 10^{-6}$ ), which one is correct?  
 (a)  $[I_2(g)] > [I^-(g)]$  (b)  $[I_2(g)] < [I^-(g)]$   
 (c)  $[I_2(g)] = [I^-(g)]$  (d)  $[I_2(g)] = \frac{1}{2}[I^-(g)]$
- 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
- $K_c$  for the reaction  

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$$
 at 300 K is  $4.0 \times 10^{-6}$ .  $K_p$  for the above reaction will be ( $R = 2 \text{ cal mol}^{-1} \text{ K}^{-1}$ )  
 (a)  $2.4 \times 10^{-3}$  (b)  $4 \times 10^{-6}$   
 (c)  $4 \times 10^{-6}(RT)^2$  (d)  $16 \times 10^{-12}$
- $\Delta G^\circ$  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
- 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)  $9.8 \times 10^{-2}$  (b)  $4.9 \times 10^{-2}$   
 (c) 416 (d)  $2.40 \times 10^{-3}$
- 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. (a) (b) (c) (d) 2. (a) (b) (c) (d) 3. (a) (b) (c) (d) 4. (a) (b) (c) (d) 5. (a) (b) (c) (d)  
 6. (a) (b) (c) (d)

Space for Rough Work

7. The degree of dissociation of dinitrogen tetroxide  $\text{N}_2\text{O}_4(\text{g}) \longrightarrow 2\text{NO}_2(\text{g})$  at temperature  $T$  and total pressure  $P$  is  $\alpha$ . Which one of the following is the correct expression for the equilibrium constant ( $K_p$ ) at this temperature?
- (a)  $\frac{2\alpha}{(1-\alpha^2)}$  (b)  $\frac{\alpha^2 P}{1-\alpha}$   
 (c)  $\frac{4\alpha^2}{(1-\alpha^2)}$  (d)  $\frac{4\alpha^2 P}{(1-\alpha^2)}$
8. The equilibrium constants  $K_{p1}$  and  $K_{p2}$  for the reactions  $\text{X} \rightleftharpoons 2\text{Y}$  and  $\text{Z} \rightleftharpoons \text{P} + \text{Q}$ , respectively are in the ratio of 1 : 9. If the degree of dissociation of  $\text{X}$  and  $\text{Z}$  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  $\text{AB}_2$  at equilibrium can be represented as :  
 $2\text{AB}_2(\text{g}) \rightleftharpoons 2\text{AB}(\text{g}) + \text{B}_2(\text{g})$   
 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  $\text{ClF}_3$  is represented by the equation :  
 $\text{Cl}_2(\text{g}) + 3\text{F}_2(\text{g}) \rightleftharpoons 2\text{ClF}_3(\text{g}); \Delta H = -329 \text{ kJ}$   
 Which of the following will increase the quantity of  $\text{ClF}_3$  in an equilibrium mixture of  $\text{Cl}_2$ ,  $\text{F}_2$  and  $\text{ClF}_3$ ?  
 (a) Adding  $\text{F}_2$   
 (b) Increasing the volume of the container  
 (c) Removing  $\text{Cl}_2$   
 (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)  $\Delta G$  is negative, then the reaction is spontaneous and proceeds in the forward direction.  
 (ii)  $\Delta G$  is positive, then reaction is non-spontaneous  
 (iii)  $\Delta G$  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  $\text{SO}_3$ ? Given that  
 $2\text{SO}_2 + \text{O}_2 \rightleftharpoons 2\text{SO}_3; \Delta H = -42 \text{ kcal}$   
 (a) Low pressure and low temperature  
 (b) High pressure and low temperature  
 (c) High temperature and low pressure  
 (d) High concentration of  $\text{SO}_2$
14. The standard Gibbs energy change at 300 K for the reaction  $2\text{A} \rightleftharpoons \text{B} + \text{C}$  is 2494.2 J. At a given time, the composition of the reaction mixture is  $[\text{A}] = \frac{1}{2}$ ,  $[\text{B}] = 2$  and  $[\text{C}] = \frac{1}{2}$ . The reaction proceeds in the :  $[R = 8.314 \text{ J/K/mol}, e = 2.718]$   
 (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  $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}(\text{g})$  is  $K_c$ , the equilibrium constant for  $\frac{1}{2}\text{N}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightleftharpoons \text{NO}(\text{g})$  will be:  
 (a)  $K^2$  (b)  $\frac{1}{2}K$   
 (c)  $K$  (d)  $K^2$
16. The following reaction is performed at 298 K.  
 $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$   
 The standard free energy of formation of  $\text{NO}(\text{g})$  is 86.6 kJ/mol at 298 K. What is the standard free energy of formation of  $\text{NO}_2(\text{g})$  at 298 K? ( $K_p = 1.6 \times 10^{12}$ )  
 (a)  $86600 - \frac{\ln(1.6 \times 10^{12})}{R(298)}$   
 (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)  $\text{NaOH}$  and  $\text{NaCl}$  (b)  $\text{HNO}_3$  and  $\text{NH}_4\text{NO}_3$   
 (c)  $\text{HCl}$  and  $\text{KCl}$  (d)  $\text{HNO}_2$  and  $\text{NaNO}_2$

RESPONSE  
GRID

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

Space for Rough Work

18. For dibasic acid correct order is  
 (a)  $K_{a1} < K_{a2}$  (b)  $K_{a1} > K_{a2}$   
 (c)  $K_{a1} = K_{a2}$  (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)  $\Delta G = 0, Q_p < K_p$  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  $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$  is 0.04 at  $250^\circ\text{C}$ . How many moles of  $\text{PCl}_5$  must be added to a 3 L flask to obtain a  $\text{Cl}_2$  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  
 $\text{A} + 3\text{B} \rightleftharpoons 2\text{C} + \text{D}$   
 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)  $\text{Na}_2\text{CO}_3$  (b)  $\text{OH}^-$   
 (c)  $\text{HCO}_3^-$  (d)  $\text{NH}_3$
23. Match the columns :  

Column-I	Column-II
A. $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$ ( $t = 300^\circ\text{C}$ )	I. $\Delta n > 0$
B. $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$ ( $t = 50^\circ\text{C}$ )	II. $K_p < K_c$
C. $\text{C}(\text{s}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + \text{H}_2(\text{g})$	III. $K_p$ not defined
D. $\text{CH}_3\text{COOH}(\text{l}) + \text{C}_2\text{H}_5\text{OH}(\text{l}) \rightleftharpoons \text{CH}_3\text{COOC}_2\text{H}_5(\text{l}) + \text{H}_2\text{O}(\text{l})$	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 ( $K_w$ ) =  $[\text{H}^+][\text{OH}^-] = 10^{-14}\text{M}^2$   
 (ii) At  $298\text{K}$   $[\text{H}^+] = [\text{OH}^-] = 10^{-7}$   
 (iii)  $K_w$  does not depend upon temperature  
 (iv) Molarity of pure water = 55.55 M  
 (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  $1.8 \times 10^{-4}$  and  $1.8 \times 10^{-6}$  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  $\text{H}_2\text{A}$  are  $1.0 \times 10^{-5}$  and  $5.0 \times 10^{-10}$  respectively. The overall dissociation constant of the acid will be  
 (a)  $0.2 \times 10^5$  (b)  $5.0 \times 10^{-5}$   
 (c)  $5.0 \times 10^{15}$  (d)  $5.0 \times 10^{-15}$
27. Equal volumes of three acid solutions of pH 3, 4 and 5 are mixed in a vessel. What will be the  $\text{H}^+$  ion concentration in the mixture?  
 (a)  $1.11 \times 10^{-4}\text{M}$  (b)  $3.7 \times 10^{-4}\text{M}$   
 (c)  $3.7 \times 10^{-3}\text{M}$  (d)  $1.11 \times 10^{-3}\text{M}$
28. The solubility product of  $\text{AgCl}$  is  $4.0 \times 10^{-10}$  at  $298\text{K}$ . The solubility of  $\text{AgCl}$  in 0.04 M  $\text{CaCl}_2$  will be  
 (a)  $2.0 \times 10^{-5}\text{M}$  (b)  $1.0 \times 10^{-4}\text{M}$   
 (c)  $5.0 \times 10^{-9}\text{M}$  (d)  $2.2 \times 10^{-4}\text{M}$
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  $\text{AgIO}_3$  (molecular mass = 283) the equilibrium which sets is  $\text{AgIO}_3(\text{s}) \rightleftharpoons \text{Ag}^+(\text{aq}) + \text{IO}_3^-(\text{aq})$ . If the solubility product constant  $K_{sp}$  of  $\text{AgIO}_3$  at a given temperature is  $1.0 \times 10^{-8}$ , what is the mass of  $\text{AgIO}_3$  contained in 100 ml of its saturated solution?  
 (a)  $1.0 \times 10^{-4}\text{g}$  (b)  $28.3 \times 10^{-2}\text{g}$   
 (c)  $2.83 \times 10^{-3}\text{g}$  (d)  $1.0 \times 10^{-7}\text{g}$
31. What is  $[\text{H}^+]$  in mol/L of a solution that is 0.20 M in  $\text{CH}_3\text{COONa}$  and 0.10 M in  $\text{CH}_3\text{COOH}$ ?  $K_a$  for  $\text{CH}_3\text{COOH} = 1.8 \times 10^{-5}$ .  
 (a)  $3.5 \times 10^{-4}$  (b)  $1.1 \times 10^{-5}$   
 (c)  $1.8 \times 10^{-5}$  (d)  $9.0 \times 10^{-6}$

RESPONSE  
GRID

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

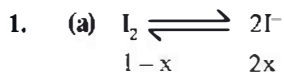
Space for Rough Work

32. The  $K_{sp}$  for  $\text{Cr}(\text{OH})_3$  is  $1.6 \times 10^{-30}$ . The solubility of this compound in water is :  
 (a)  $\sqrt[4]{1.6 \times 10^{-30}}$  (b)  $\sqrt[4]{1.6 \times 10^{-30}}/27$   
 (c)  $1.6 \times 10^{-30/27}$  (d)  $\sqrt[4]{1.6 \times 10^{-30}}$
33. For the reaction  $\text{CO}(\text{g}) + (1/2)\text{O}_2(\text{g}) = \text{CO}_2(\text{g})$ ,  $K_p/K_c$  is  
 (a)  $RT$  (b)  $(RT)^{-1}$   
 (c)  $(RT)^{-1/2}$  (d)  $(RT)^{1/2}$
34. For the reaction :  $2\text{NO}_{2(\text{g})} \rightleftharpoons 2\text{NO}_{(\text{g})} + \text{O}_{2(\text{g})}$ ,  
 ( $K_c = 1.8 \times 10^{-6}$  at  $184^\circ\text{C}$ ) ( $R = 0.0831 \text{ kJ}/(\text{mol} \cdot \text{K})$ )  
 When  $K_p$  and  $K_c$  are compared at  $184^\circ\text{C}$ , 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**  $K_a$   
 $\text{HCN}$   $6.2 \times 10^{-10}$   
 $\text{HF}$   $6.6 \times 10^{-4}$   
 $\text{HNO}_2$   $7.2 \times 10^{-4}$   
 Correct order of increasing base strength of the base  $\text{CN}^-$ ,  $\text{F}^-$  and  $\text{NO}_2^-$  will be :  
 (a)  $\text{F}^- < \text{CN}^- < \text{NO}_2^-$  (b)  $\text{NO}_2^- < \text{CN}^- < \text{F}^-$   
 (c)  $\text{F}^- < \text{NO}_2^- < \text{CN}^-$  (d)  $\text{NO}_2^- < \text{F}^- < \text{CN}^-$
37. How many litres of water must be added to 1 litre of an aqueous solution of  $\text{HCl}$  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  $\text{HCOONH}_4$ ,  $\text{p}K_a$  of  $\text{HCOOH}$  is 3.8 and  $\text{p}K_b$  of  $\text{NH}_3$  is 4.8  
 (a) 6.5 (b) 4.8  
 (c) 3.8 (d) 8.6
39. Solid  $\text{Ba}(\text{NO}_3)_2$  is gradually dissolved in a  $1.0 \times 10^{-4} \text{ M}$   $\text{Na}_2\text{CO}_3$  solution. At what concentration of  $\text{Ba}^{2+}$  will a precipitate begin to form? ( $K_{sp}$  for  $\text{BaCO}_3 = 5.1 \times 10^{-9}$ )  
 (a)  $5.1 \times 10^{-5} \text{ M}$  (b)  $8.1 \times 10^{-8} \text{ M}$   
 (c)  $8.1 \times 10^{-7} \text{ M}$  (d)  $4.1 \times 10^{-5} \text{ M}$
40. Solubility product of silver bromide is  $5.0 \times 10^{-13}$ . The quantity of potassium bromide (molar mass taken as  $120 \text{ g mol}^{-1}$ ) to be added to 1 litre of 0.05 M solution of silver nitrate to start the precipitation of  $\text{AgBr}$  is  
 (a)  $1.2 \times 10^{-10} \text{ g}$  (b)  $1.2 \times 10^{-9} \text{ g}$   
 (c)  $6.2 \times 10^{-5} \text{ g}$  (d)  $5.0 \times 10^{-8} \text{ g}$
41. Three reactions involving  $\text{H}_2\text{PO}_4^-$  are given below :  
 (i)  $\text{H}_3\text{PO}_4 + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{H}_2\text{PO}_4^-$   
 (ii)  $\text{H}_2\text{PO}_4^- + \text{H}_2\text{O} \rightarrow \text{HPO}_4^{2-} + \text{H}_3\text{O}^+$   
 (iii)  $\text{H}_2\text{PO}_4^- + \text{OH}^- \rightarrow \text{H}_3\text{PO}_4 + \text{O}^{2-}$   
 In which of the above does  $\text{H}_2\text{PO}_4^-$  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)  $10^{-4} \text{ M KOH}$  (b)  $10^{-10} \text{ M KOH}$   
 (c)  $10^{-10} \text{ M HCl}$  (d)  $10^{-4} \text{ M HCl}$
43. Calculate the pH of 0.5 M aqueous solution of  $\text{NaCN}$ , the  $\text{p}K_b$  of  $\text{CN}^-$  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)  $\text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + \text{H}_2(\text{g}); K_1$   
 (ii)  $\text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + 3\text{H}_2(\text{g}); K_2$   
 (iii)  $\text{CH}_4(\text{g}) + 2\text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + 4\text{H}_2(\text{g}); K_3$   
 (a)  $K_1\sqrt{K_2} = K_3$  (b)  $K_2K_3 = K_1$   
 (c)  $K_3 = K_1K_2$  (d)  $K_3 \cdot K_2^3 = K_1^2$
45. A vessel at 1000 K contains  $\text{CO}_2$  with a pressure of 0.5 atm. Some of the  $\text{CO}_2$  is converted into  $\text{CO}$  on the addition of graphite. If the total pressure at equilibrium is 0.8 atm, the value of  $K$  is :  
 (a) 1.8 atm (b) 3 atm  
 (c) 0.3 atm (d) 0.18 atm

RESPONSE  
GRID

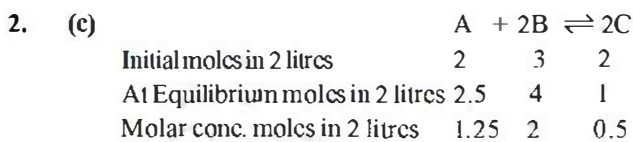
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|---------------------|---------------------|---------------------|---------------------|---------------------|
| 32. (a) (b) (c) (d) | 33. (a) (b) (c) (d) | 34. (a) (b) (c) (d) | 35. (a) (b) (c) (d) | 36. (a) (b) (c) (d) |
| 37. (a) (b) (c) (d) | 38. (a) (b) (c) (d) | 39. (a) (b) (c) (d) | 40. (a) (b) (c) (d) | 41. (a) (b) (c) (d) |
| 42. (a) (b) (c) (d) | 43. (a) (b) (c) (d) | 44. (a) (b) (c) (d) | 45. (a) (b) (c) (d) |                     |

Space for Rough Work

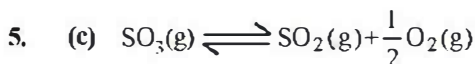
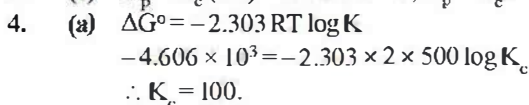
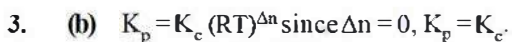


$$K_c = \frac{(2x)^2}{(1-x)} = 10^{-6}$$

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



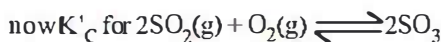
$$K_c = \frac{(0.5)^2}{(1.25)(2)^2} = 0.05$$



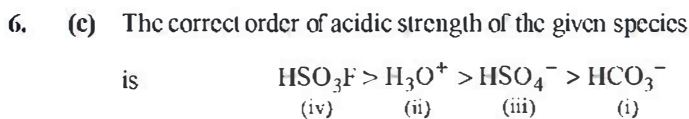
$$K_c = \frac{[SO_2][O_2]^{1/2}}{[SO_3]} = 4.9 \times 10^{-2},$$

On taking the square of the above reaction

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

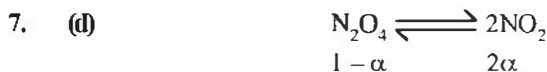


$$= \frac{[SO_3]^2}{[SO_2]^2[O_2]} = \frac{1}{24.01 \times 10^{-4}} = 416$$



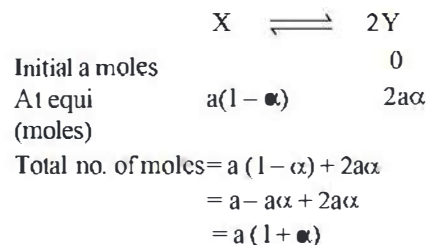
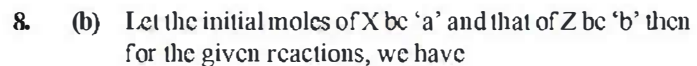
or (i) < (iii) < (ii) < (iv)

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



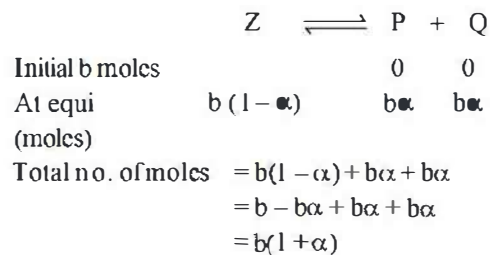
Total moles at equ =  $1-\alpha+2\alpha=1+\alpha$

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



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

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



$$\text{Now } K_{P_2} = \frac{n_Q \times n_P}{n_Z} \times \left[\frac{P_{T_2}}{\sum n}\right]^{\Delta n}$$

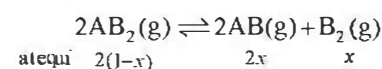
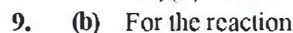
$$\text{or } K_{P_2} = \frac{(b\alpha)(b\alpha)P_{T_2}}{[b(1-\alpha)][b(1+\alpha)]}$$

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

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

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

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



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

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

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

Total number of moles

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

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

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

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

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

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

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

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

$$= \frac{x^3 \cdot P^3}{2 \times 1 \times P^2} \quad [\because 1-x \approx 1]$$

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

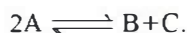
10. (a) The reaction given is an exothermic reaction thus according to Le Chatelier's principle lowering of temperature, addition of  $F_2$  and  $Cl_2$  favour the forward direction and hence the production of  $ClF_3$ .

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)  $\Delta G^\circ = 2494.2 \text{ J}$



$$R = 8.314 \text{ J/K/mol.}$$

$$c = 2.718$$

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

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

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

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

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

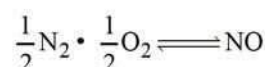
$$\Rightarrow \log K_c = -0.4341$$

$$K_c = 0.37$$

$$Q > K_c$$

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

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



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

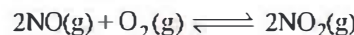
16. (b)  $\Delta G^\circ_{NO(g)} = 86.6 \text{ kJ/mol} = 86600 \text{ J/mol}$

$$G^\circ_{N_2(g)} = x \text{ J/mol}$$

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

$$\Delta G^\circ = -RT \ln K_p$$

Given equation,



$$\therefore 2\Delta G^\circ_{NO_2} - 2\Delta G^\circ_{NO} = -R(298) \ln(1.6 \times 10^{12})$$

$$2\Delta G^\circ_{NO_2} - 2 \times 86600 = -R(298) \ln(1.6 \times 10^{12})$$

$$2\Delta G^\circ_{NO_2} = 2 \times 86600 - R(298) \ln(1.6 \times 10^{12})$$

$$\Delta G^\circ_{NO_2} = \frac{1}{2} [2 \times 86600 - R(298) \ln(1.6 \times 10^{12})]$$

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

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.,  $K_{a1} > K_{a2}$



19. (b) Van't Hoff reaction isotherm is  $\Delta G = \Delta G^\circ + RT \ln Q_p$   
When the reaction is in a state of equilibrium  $\Delta G = 0$

$$\text{Then } \Delta G^\circ = -RT \ln Q_p = -RT \ln K_p$$

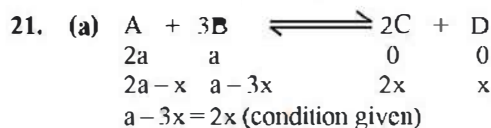
20. (b) At equilibrium the moles of  $Cl_2$  must be  $0.15 \times 3 = 0.45$



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

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

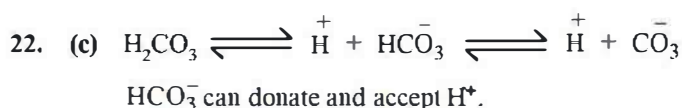
$$\therefore 0.04 = \frac{0.15 \times 0.15}{(x-0.45)/3} \quad \therefore x = 2.1 \text{ moles}$$



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

The % of B reacted is

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



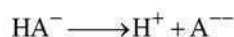
23. (a) (A)  $K_p = K_c (RT)^{\Delta n}$
- $$\frac{K_p}{K_c} = (RT)^{\Delta n} \text{ as } \Delta n = -ve \Rightarrow K_p < K_c$$
- (B)  $\Delta n > 0$
- (C)  $\Delta n = 2 - 1 = 1$
- (D) As the reaction is not containing any gaseous component therefore  $K_p$  is not defined for this.

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.



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



$$\therefore K_2 = 5.0 \times 10^{-10} = \frac{[H^+][A^{2-}]}{[HA^-]} \text{ (Given)}$$

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

$$= (1.0 \times 10^{-5}) \times (5.0 \times 10^{-10}) = 5 \times 10^{-15}$$

27. (b)  $[H_3O]^+$  for a solution having pH = 3 is given by
- $$[H_3O]^+ = 1 \times 10^{-3} \text{ moles/litre}$$
- $$[\therefore [H_3O]^+ = 10^{-pH}]$$

Similarly for solution having pH = 4,

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

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

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  $= (10^{-3} + 10^{-4} + 10^{-5}) \text{ moles}$

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

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

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

28. (c) Solubility of AgCl

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

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

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

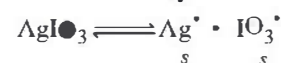
$$= -\log K_b \left( \text{since } \frac{[SALT]}{[BASE]} = 1 \right)$$

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

$$pH + pOH = 14$$

$$\therefore pH = 9.3$$

30. (c) Let  $s$  = solubility



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

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

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

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

( $\because$  Molecular mass of  $AgIO_3 = 283$ )

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

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

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

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

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

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

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

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

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

$$27s^4 = K_{sp}$$

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

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:  $2\text{NO}_2(\text{g}) \rightleftharpoons 2\text{NO}(\text{g}) + \text{O}_2(\text{g})$

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

$R = 0.0831 \text{ kJ/mol.K}$

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

$[\because 184^\circ\text{C} = (273 + 184) = 457\text{K}, \Delta n = (2 + 1, -1) = 1]$

Hence it is clear that  $K_p > K_c$



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

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

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

$$\alpha = \sqrt{\frac{K_a}{C}} = \sqrt{\frac{2 \times 10^{-8}}{0.005}} = \sqrt{4 \times 10^{-6}} = 2 \times 10^{-3}$$

Percentage ionization = 0.2

36. (c) Higher the value of  $K_a$ , lower will be the value of  $\text{p}K_a$  i.e. higher will be the acidic nature. Further since  $\text{CN}^-$ ,  $\text{F}^-$  and  $\text{NO}_2^-$  are conjugate base of the acids  $\text{HCN}$ ,  $\text{HF}$  and  $\text{HNO}_2$  respectively hence the correct order of base strength will be  $\text{F}^- < \text{NO}_2^- < \text{CN}^-$

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

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

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

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

$M_2 = 0.01$   $V_2 = ?$

From

$M_1 V_1 = M_2 V_2$

$0.1 \times 1 = 0.01 \times V_2$

$V_2 = 10 \text{ litres}$

$\therefore$  Volume of water added =  $10 - 1 = 9 \text{ litres}$

38. (a)  $\text{HCOONH}_4$  is a salt of weak acid and weak base;

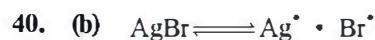
$\text{pH} = \frac{1}{2} \text{p}K_w + \frac{1}{2} \text{p}K_a - \frac{1}{2} \text{p}K_b$

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



$K_{\text{SP}}(\text{BaCO}_3) = [\text{Ba}^{2+}][\text{CO}_3^{2-}]$

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



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

For precipitation to occur

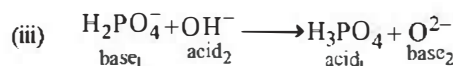
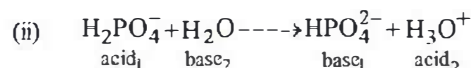
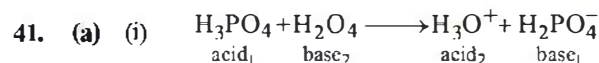
Ionic product > Solubility product

$$[\text{Br}^-] \cdot \frac{K_{\text{sp}}}{[\text{Ag}^+]} \cdot \frac{5 \cdot 10^{-13}}{0.05} \cdot 10^{-11}$$

i.e., precipitation just starts when  $10^{-11}$  moles of  $\text{KBr}$  is added to  $1 \text{ l}$   $\text{AgNO}_3$  solution

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

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



Hence only in (ii) reaction  $\text{H}_2\text{PO}_4^-$  is acting as an acid.

42. (a)  $\text{pOH} = -\log [\text{OH}^-]$

$\text{pH} + \text{pOH} = 14$

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

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

$\text{pH} = 14 - \text{pOH} = 10$

43. (b)  $\text{NaCN}$  is a salt of strong base and weak acid;  $\text{pH}$

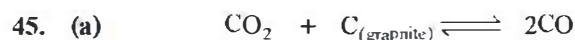
$$= 7 + \frac{1}{2} \text{p}K_a + \frac{1}{2} \log C$$

$\text{p}K_a$  for  $\text{HCN} = 14 - 4.70 = 9.30$

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

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

Hence (c) is the correct answer.



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

$P_{\text{final}} \quad (0.5 - x) \text{ atm} \quad 2x \text{ atm}$

Total  $P$  at equilibrium =  $0.5 - x + 2x = 0.5 + x \text{ atm}$

$0.8 = 0.5 + x$

$\therefore x = 0.8 - 0.5 = 0.3 \text{ atm}$

Now  $k_p = (P_{\text{CO}})^2 / P_{\text{CO}_2}$

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