Chemical Equilibrium

SOLUTIONS

EXERCISE - O

1. Ans. (B)

At equilibrium,

Rate of forward reaction = rate of backward reaction

2. Ans. (C)

$A \rightleftharpoons B$

$$K_{eq} = \frac{k_f}{k_b} = \frac{[B]_{eq}}{[A]_{eq}}$$

$$[B]_{eq} = \frac{k_f}{k_b}[A]_{eq}$$

3. Ans. (D)

At equilibrium, measurable properties become constant, $r_f = r_b$ and net rate of reaction is zero.

4. Ans. (C)

$$K_{eq} = \frac{k_f}{k_b}$$

5. Ans. (D)

Precipitation reaction, neutralisation reaction is irreversible reaction.

6. Ans. (B)

$$[HI] = \frac{64}{128 \times 2} = \frac{1}{4} = 0.25\,M$$

7. Ans. (C)

Equilibrium constant is independent of initial concentration of reactants.

8. Ans. (B)

	A +	B	⇌	C +	D
Initial	4 mole	4 mole		0	0
Final	4 – x	4 – x		x	x

x = 2 (according to problem)

{volume is cancelled in expression of K_{eq}}

$$K_{eq} = \frac{x^2}{(4-x)^2} = \frac{(2)^2}{(4-2)^2} = 1$$

9. Ans. (C)

Gas product concentration increases while that of solid reactant is constant.

10. **Ans. (C)**

$A + 3B \rightleftharpoons 2C; \qquad K_p = 9\ atm^{-2}$

$\frac{A}{2} + \frac{3B}{2} \rightleftharpoons C; \qquad K' = (9)^{\frac{1}{2}}$

$K' = 3atm^{-1}$

11. **Ans. (D)**

$2HI \rightleftharpoons H_2 + I_2$

$1-\alpha \qquad \frac{\alpha}{2} \qquad \frac{\alpha}{2}$

$$\therefore K_P = \frac{\left[\frac{\alpha \times P}{2}\right]^2}{\left[\frac{1-\alpha}{1} \times P\right]^2}$$

$$\therefore K_P = \frac{\alpha^2}{4(1-\alpha)^2}$$

By taking root at both side

$$\sqrt{K_P} = \frac{\alpha}{2(1-\alpha)}$$

$$\therefore 2\sqrt{K_P} - 2\alpha\sqrt{K_P} = \alpha$$

$$\therefore 2\sqrt{K_P} = \alpha + 2\alpha\sqrt{K_P}$$

$$\therefore \alpha = \frac{2\sqrt{K_P}}{1+2\sqrt{K_P}}$$

12. **Ans. (D)**

$K_C > 10^3$ (Reaction proceeds almost to completion)

$K_C > 10^{-3}$ (Reaction hardly proceeds)

$10^{-3} < K_C < 10^3$(Both reactant and product are present at equilibrium)

13. **Ans. (C)**

$n_{NH_4H_5} = \frac{5.1}{51} = 0.1$ mole

Moles of $NH_4HS = 0.1$

	$NH_4HS(s)$	$\rightleftharpoons$	$NH_3(g)$	+	$H_2S(g)$
Initial moles	0.1				
Final at equilibrium			0.03		0.03
Moles			0.03		0.03

$K_C = \left(\frac{0.03}{3}\right) \times \left(\frac{0.03}{3}\right)$

$K_C = 10^{-4}\ M^2$

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

$= 10^{-4} \times (0.082 \times 600)^2$

$= 0.242\ atm^2.$

14. Ans. (D)

(a) $X(s) \rightleftharpoons \underset{P}{A(g)} + \underset{P}{C(g)}; \quad K_{P_1}$

$2P = 40 \Rightarrow P = 20$

$K_{P_1} = 20 \times 20 = 400\ mm^2$

$Y(s) \rightleftharpoons \underset{P}{A(g)} + \underset{P}{C(g)}; \quad K_{P_2}$

$2P = 60 \Rightarrow P = 30$

$K_{P_2} = 30 \times 30 = 900\ mm^2$

15. Ans. (D)

On addition of inert gas at constant temperature & pressure, 2nd reaction will be shifted in backward direction.

16. Ans. (A)

$$SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g)\ ;\ K_1 \qquad ...(1)$$

$$4SO_3(g) \rightleftharpoons 4SO_2(g) + 2O_2(g)\ ;\ K_2 \qquad ...(2)$$

Reaction (2) is obtained by reversing, reaction (1) and multiplying by 4.

So, $K_2 = \frac{1}{(K_1)^4}$

17. Ans. (D)

Catalyst lowers the activation energy and reduces the time to attain equilibrium.

18. Ans. (A)

	$2NO$	$\rightleftharpoons$	N_2	+	O_2	
α=10%	4–0.4		0.2		0.2	at equilibrium.
	= 3.6		0.2		0.2	

For this reaction $\Delta n_g = 0$, so $K_P = K_C$

$$K_P = K_C = \frac{[N_2][O_2]}{[NO]^2} = \frac{\left(\frac{0.2}{0.25}\right)\left(\frac{0.2}{0.25}\right)}{\left(\frac{3.6}{0.25}\right)^2} = \frac{1}{(18)^2}$$

19. Ans. (C)

$Q < K_C \Rightarrow$ Reaction moves forward

20. Ans. (D)

At point A, $Q_P = \tan 60°$

$Q_P = 1.732$

$\therefore \quad Q_P = K_P = 1.732$

21. Ans. (B)

$K_p = 0.800$ atm = P_{CO_2} = maximum pressure of CO_2 in the container to calculate maximum volume of container the P_{CO_2} = 0.8 atm and none of CO_2 should get converted into $CaCO_3(s)$.

So, V(0.800 atm) = (10 L) (0.2 atm)

So, V = 2.5 L

22. Ans. (C)

If total pressure decreases, reaction move in that direction where gaseous moles are more.

23. Ans. (B)

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

Exothermic reaction, so low temperature is favourable also high pressure is favourable as $\Delta n_g < 0$, reaction will proceed forward.

24. Ans. (C)

High Pressure & low temperature is favourable.

25. Ans. (A)

Yes, as pressure is increased, reaction will shift towards lesser number of gaseous moles.

26. Ans. (B)

On increasing pressure, reaction move in that direction where gaseous moles are produced less.

27. Ans. (C)

Addition of inert gas at constant volume doesn't effect equilibrium.

28. Ans. (A,B,D)

(A) Catalyst has no effect on equilibrium state.

(B) Equilibrium constant is independent of initial concentration of reaction.

(D) Equilibrium constant is independent of pressure.

29. Ans. (A,D)

	$PCl_5(g)$	$\rightleftharpoons$	$PCl_3(g)$ +	$Cl_2(g)$
Initial moles	1		1	0
Equ. moles	1 – x		1 + x	x
	≈ 1		≈ 1	= 0.004

$$\therefore K_C = \frac{1 \times 0.004}{1} \times \left(\frac{1}{10}\right) = 0.0004 \text{ M}$$

30. Ans. (A,B,C)

$$NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g)$$

Equ. partial pressure	0.2 atm	0.2 atm
Second Equ. partial pressure	0.5 atm	P atm

Now, $K_P = 0.2 \times 0.2 = 0.5 \times P \Rightarrow P = 0.08$

31. Ans. (A,B)

$\Delta ng = 0$

32. Ans. (A,B,C)

$$N_2O_5(g) \rightleftharpoons 2NO_2(g) + \frac{1}{2}O_2(g)$$

Initial partial pressure	P_0	0	0
Equ. partial pressure	$P_0(1-\alpha)$	$2\alpha P_0$	$\frac{\alpha P_0}{2}$ and $\frac{M-2D}{\left(\frac{5}{2}-1\right)\cdot 2D}=\frac{M-2D}{3D}$

Total equilibrium pressure = $P_0(1-\alpha) + 2\alpha P_0 + \frac{\alpha P_0}{2} = P_0\left(1+\frac{3\alpha}{2}\right)$

33. Ans. (A,B,C)

$K_{P_2} = P_{Cl_2(g)} = 0.2$

$K_{P_2} = P_{Cl_2(g)} \cdot P^8_{H_2O(g)} = 0.2 \times (0.001)^8 = 2 \times 10^{-25}$ atm^9

$P_{H_2(O)_{(g)}}$ = Vapour pressure of ice.

34. Ans. (A,C)

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

Initial moles	5	0	0
Moles at equilibrium	$5-\alpha$	x	x

From question, $(5-x) + x + x + 4 = \frac{4.8\times 112}{0.0821\times 546}$

$\Rightarrow x = 3$

$\therefore \alpha = \frac{x}{5} = 0.6$

and $K_P = \frac{x \cdot x}{5-x}\cdot\left(\frac{4.8}{12}\right) = 1.8$ atm

35. Ans. (A,B,C,D)

$$4HCl(g) + O_2(g) \rightleftharpoons 2Cl_2(g) + 2H_2O(g)$$

Initial partial pressure	1.0 atm	0.25 atm	0	0.4 atm
On completion	0	0	0.5 atm	0.4 atm
Equ. partial pressure	4x	x atm	0.5 atm	0.4 atm

$K_P = 5\times 10^{12} = \frac{(0.5)^2(0.4)^2}{(4x)^4 \times x} \Rightarrow x = 5 \times 10^{-4}$

36. Ans. (A,B)

Le Chatelier's principle

37. Ans. (A,B,C)

(A) increase in the rate of forward reaction. (B) increase in the rate of reverse reaction.
(C) a new reaction pathway to reaction.

38. Ans. (D)

Vapour pressure of a particular liquid system depends only on temperature.

39. Ans. (B,C)

$Cl_2(g) \rightleftharpoons 2Cl(g)$ $T\uparrow$ $P\downarrow$

40. Ans. (B,C)

Addition of insert gas at constant pressure shifts the equilibrium in the direction of increase in moles of gases.

41. Ans. (A,B,D)

Decrease in pressure favors the reaction is the direction of increase in moles of gas and hence, B should be monomer.

42. Ans. (A,D)

At 300K : $G° = (-41) - 300 \times (-0.04)$

$= -29$ KJ/mol

Hence, the reaction is spontaneous in forward direction.

At 1200 K : $G° = (-33) - 1200 \times (-0.03)$

$= +3$ KJ/mol

Hence, the reaction is spontaneous in backward direction.

43. Ans. (B,C)

Theory based.

44. Ans. (A,B)

Theory based.

45. Ans. (A,B,C)

Theory based.

46. Ans. (A,B)

$$\Delta G^\circ = 2 \times \Delta_f G^\circ_{N_2O_{4(g)}} - \Delta_f G^\circ_{N_2O_{4(g)}} = 0$$

$$\Rightarrow \quad K_P^\circ = 1$$

Now, $\Delta G = \Delta G° + RT \cdot \ln Q = 0 + RT \cdot \ln \frac{P^2_{NO_2}}{P_{N_2O_4}}$

$= RT \cdot \ln \frac{10^2}{10}$ = positive

47. Ans. (A)

(A) Δn_g is positive so as pressure is increased, backward shifting will take place. Total pressure even after shifting will remain same.

(B) Δn_g is negative so as volume is increased, backward shifting will take place. But $P_{final} < P_{initial}$.

(C) No change but $P_{final} < P_{initial}$ as volume has increased.

(D) Forward shifting will take place and $P_{final} < P_{initial}$.

EXERCISE - S

1. Ans. (0.20)

	A(g)	+ 2B(g) $\rightleftharpoons$	C(g)	+ D(g)
In moles:	0.5	1	0.5	3.5
[Eqm]	0.5 – x	1 – 2x	0.5 + x	3.5 + x
	y	= 2y	1.0	4

$K_C = 10^{12} = \frac{1 \times 4}{y(2y)^2} \Rightarrow y = 10^{-4}$ M

$[B]_{eq} = 2y = 2 \times 10^{-4}$ M

2. Ans. (0.36 or 0.37)

	PCl_5	$\rightleftharpoons$ PCl_3	+ Cl_2
t = 0	$\frac{1}{10}$ M	—	—
Eqm	0.1 – x	x	x

$K_C = 10^{-2} = \frac{x^2}{0.1 - x}$

$x^2 + 10^{-2}x - 10^{-3} = 0$

$x = -\frac{10^{-2} + \sqrt{10^{-4} + 4 \times 10^{-3}}}{2 \times 1}$

$= -\frac{10^{-2} + \sqrt{41 \times 10^{-4}}}{2}$

$= -\frac{10^{-2} + 6.4 \times 10^{-2}}{2}$

$= \frac{5.4 \times 10^{-2}}{2}$

$= 2.7 \times 10^{-2}$ M

3. Ans. (a) 6.66 or 0.67, (b) 375.00, (c) 10.45 or 10.46, (d) 6.25

(a) $K_P = K_C(RT)^{\Delta ng}$

$K_C = \frac{0.1642}{(0.0821 \times 300)^1} = 6.67 \times 10^{-3} M = \frac{2}{300} M$

(b)

	N_2O_4	$\rightleftharpoons$	$2NO_2$
	$\frac{36.8}{92} = 0.4$ mol		—
eqn	0.4 – x		2x

$n_{N_2O_4} = 0.4 - 0.025 = 0.375$

$n_{NO_2} = 0.05$

$$K_C = \frac{2}{300} = \frac{(2x)^2}{0.4 - x}$$

$1200x^2 + 2x - 0.8 = 0$

$$x = -\frac{2 + \sqrt{4 + 3840}}{2 \times 1200} = \frac{60}{2400} = 0.025$$

(c) $\alpha = \frac{x}{0.4} = 0.0625$

$$K_P = 4\, P_T \frac{\alpha^2}{1 - \alpha^2}$$

$$0.1642 = 4\, P_T \times \frac{0.00390625}{0.99609375}$$

$P_T = 10.47$ atm

(d) % disso = 6.25%

4. Ans. (i) 2, (ii) 1.20

(i)

	A	$\rightleftharpoons$	nB
t = 0	0.6		—
t = 1	0.6 – 0.1		0.1n = 0.2

$\Rightarrow n = 2$

(ii) $K = \frac{[B]^2}{[A]} = \frac{0.6}{0.3} = 1.2N$

(iii) $\left(-\frac{d[A]}{dt}\right)_{0 \text{ to } 1} = \frac{0.1M}{1 \text{ hr}}$

5. Ans. (2.40)

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

300 K	1 atm	—	
600 K	2 atm	—	$P \propto T$ (V, n)
After dissociation.	2 – 0.4 = 1.6 atm	0.8 atm	

% dissociation = 20%

$P_T = 2.40$ atm

6. Ans. (3.44)

$NH_2COONH_4(s) \rightleftharpoons 2NH_3(g) + CO_2(g)$

at eqm Pr.	—	2P	P
New eqm Pr.	—	3P	P – x

$K_P = K_P$

$(2P)^2 \cdot P = (3P)^2 (P - x)$

$$\frac{4}{9}P = P - x$$

$$x = \frac{5}{9}P$$

$$\frac{(P_T)_{\text{New eq}^m}}{(P_T)_{\text{old eq}^m}} = \frac{4P - x}{3P} = \frac{4P - \frac{5}{9}P}{3P} = \frac{31}{3\times 9} = \frac{31}{27}$$

$$\frac{31}{27}\times 3 = 3.44$$

Ans = $\frac{31}{27}\times 3 = 3.44$

7. Ans. (54.00)

	H_2	+	I_2	$\rightleftharpoons$	2HI;
t = 0;	1.5	a			—
At eqbm:	1.5	a – x	a – x		2x

$$\frac{n_{I_2}}{n_{HI}} = \frac{a-x}{2x} = \frac{1}{18}$$

$\Rightarrow$ x = 0.9 a

$$K_C = \frac{[HI]^2}{[H_2][I_2]} = \frac{(1.8a)^2}{(0.6a)\,(0.1a)} = 54$$

moles at eq^m

$n_{H_2} = 0.6a;\ n_{I_2} = 0.1a;\ n_{HI} = 1.8a$

But $a = \frac{127}{2\times 127} = 0.5$ (Initial moles of I_2)

$\Rightarrow$ $n_{H_2} = 0.3;\ n_{I_2} = 0.05;\ n_{HI} = 0.9$

8. Ans. (3.60)

$$2H_2O(g) + 2Cl_2(g) \rightleftharpoons 4HCl(g) + O_2(g)\ ;\ K_P = 12\times 10^8$$

t = 0;	$\frac{380}{760}$ = 0.5 atm	2 atm	2 atm	2 atm
at eq^m;	0.5	PCl_2	2+4=6	2+1=3

(Vapour pressure remain same)

[As K_P is large so reaction goes to almost completion but as water is in excess, so Cl_2 is L.R.]

$$K_P = \frac{P_{HCl}^4 \times P_{O_2}}{P_{H_2O}^2 \times P_{Cl_2}^2} = \frac{(6)^4\times 3}{(0.5)^2\times P_{Cl_2}^2}$$

$P_{Cl_2} = 3.6\times 10^{-3}$ atm

9. Ans. (a) 400, 900, (b) 4 : 9, (c) 72.15

(a) $X(S) \rightleftharpoons A(g) + C(g);\quad K_{P_1}$

P P

$2P = 40 \Rightarrow P = 20$

$K_{P_1} = 20\times 20 = 400\ mm^2$

$y(s)\ B(g) + C(g)$:
$\quad P \quad P$

$2P = 60 \Rightarrow P = 30$

$= 30 \times 30 = 900\ mm^2$

(b) $X(s) \rightleftharpoons A(g) + C(g);\ K_{P_1} = 400$
$\quad x \quad (x+y)$

$Y(s) \rightleftharpoons B(g) + C(g);\ K_{P_2} = 900$
$\quad y \quad (x+y)$

$K_{P_1} = x(x+y) = 400 \quad ...(1)$

$K_{P_2} = y(x+y) = 900 \quad ...(2)$

$\frac{eq.(1)}{eq.(2)} \Rightarrow \frac{x}{y} = \frac{4}{9}$

(c) eq. (1) + eq. (2)

$(x+y)\ \ (x+y) = 400 + 900$

$(x+y) = \sqrt{1300}$

$P_{total} = P_A + P_B + P_C = 2(x+y)$

$= 2 \times \sqrt{1300} = 72.15\ mmHg$

10. Ans. (4.00)

$A(g) \rightleftharpoons B(g) + C(g);\ K_{C_1}$
$1 \quad — \quad —$
$1-x \quad (x+y) \quad (x-y)$

$C(g) \rightleftharpoons D(g) + B(g);\ K_{C_2}$
$x-y \quad y \quad (x+y)$

$PV = nRT$

at constant V, $T \Rightarrow p \propto n$

given $2 = \frac{P_{eqbm}}{P_{initial}} = \frac{n_{eqbm}}{n_{initial}} = \frac{\overset{A}{(1-x)} + \overset{B}{(x+y)} + \overset{C}{(x-y)} + \overset{D}{y}}{1}$

$\Rightarrow \quad 1 + x + y = 2 \Rightarrow (x+y) = 1 \quad ...(1)$

also given

$\frac{[C]}{[B]} = \frac{x-y}{x+y} = \frac{1}{5} \quad \Rightarrow \quad x = \frac{3}{2}y \quad ...(2)$

from (1) & (2) $\Rightarrow x = 0.6$ & $y = 0.4$

$$\frac{K_{C_2}}{K_{C_1}} = \frac{(x+y)\frac{y}{(x-y)}}{(x+y)\frac{(x-y)}{(1-x)}} = 4$$

11. **Ans.** $K_{P_1} = \frac{1}{20P_0^2}$

	$N_2(g)$ +	$3H_2(g)$	$\rightleftharpoons 2NH_3(g)$;	K_{P_1}
t = 0;	9a	13a	—	
at eqbm:	(9a – x – y)	(13a – 3x– 2y) = $2P_0$	2x = P_0	

	$N_2(g)$ +	$2H_2(g)$	$\rightleftharpoons N_2H_4(g)$;	K_{P_2}
t = 0;	9a	13a	—	
at eqbm:	(9a – x – y)	(13a – 3x – 2y) = $2P_0$	y	

at eqbm

$P_{total} = P_{N_2} + P_{H_2} + P_{NH_3} + P_{N_2H_4}$

$7P_0 = (9a - x - y) + 2P_0 + P_0 + y$

$\Rightarrow \quad a = 0.5\ P_0$

also $P_{H_2} = 2P_0 = 13a - 3x - 2y$

$\Rightarrow \quad y = 1.5\ P_0$

So at eqbm $\Rightarrow P_{N_2} = 2.5\ P_0$; $P_{N_2H_4} = 1.5\ P_0$

$P_{H_2} = 2P_0$; $P_{NH_3} = P_0$

$K_{P_1} = \frac{1}{20P_0^2}$

$K_{P_2} = \frac{(1.5P_0)}{(2.5P_0)(2P_0)^2} = \frac{3}{20P_0^2}$

12. **Ans. (a) 80, (b) 0.15, (c) 26.08 or 26.09**

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

at t = 0;	1	—
at eqbm;	1 – α	2α

(a) Abnormal $M_w = 2 \times (V.D.)_{mixture} = 2 \times 42 = 84$

(b) $M_{avg} = \frac{\text{Mass of mixture}}{\text{total moles}}$

$84 = \frac{1 \times 92}{1 - \alpha + 2\alpha} = \frac{92}{1 + \alpha}$

$1 + \alpha = \frac{92}{84} = 1 + \frac{8}{84}$

$\alpha = 0.095$

(M_w of $N_2O_4 = 92$)

(c) $\%NO_2 = \frac{\text{moles of } NO_2}{\text{total moles in mixture}} \times 100$

$= \frac{2\alpha}{1+\alpha} \times 100$

$= \frac{2 \times 0.095}{(1+0.95)} \times 100 = 17.35\%$

13. Ans. (0.11)

$NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g)$

t = 0 — 0.5 atm —

At eqm. — 0.5 + P P

$0.5 + 2P = 0.84$

$2P = 0.34$

$P = 0.17$ atm

$K_P = P_{NH_3} \cdot P_{H_2S}$

$= (0.5 + 0.17)(0.17)$ atm^2

$= 0.67 \times 0.1$

7 atm^2

$= 0.1139$ atm^2

14. Ans. ($SrCl_2 . 2H_2O$)

Drying agent absorb moisture, so reaction should proceed in backward direction

i.e. $Q_P > K_P$ i.e. $P_{H_2O(air)} > P_{H_2O(at\ eqbm)}$

$\Rightarrow$ $P_{H_2O(at\ eqbm)}$ should be least for most effective drying agent

$SrCl_2 \cdot 2H_2O \Rightarrow K_P = (P_{H_2O})^4 \Rightarrow P_{H_2O(eqbm)} = (5 \times 10^{-12})^{1/4} = 1.5 \times 10^{-3}$

$Na_2HPO_4 \cdot 7H_2O \Rightarrow K_P = (P_{H_2O})^7 \Rightarrow P_{H_2O(eqbm)} = (2.43 \times 10^{-13})^{1/7} = 4.75 \times 10^{-3}$

$Na_2SO_4 \Rightarrow K_P = (P_{H_2O})^{10} \Rightarrow P_{H_2O(eqbm)} = (1.024 \times 10^{-27})^{1/10} = 2 \times 10^{-3}$

for $SrCl_2 \cdot 2H_2O(s) \Rightarrow P_{H_2O(eqbm)}$ is least

15. Ans. (10.00)

$NO_2(g) + NO(g) \rightleftharpoons N_2O(g) + O_2(g)$; $K_C = 1$

moles initially a a — —

at eqbm a – x a – x x x

$K_C = 1 \frac{x \cdot x}{(a-x)(a-x)}$

$\Rightarrow 1 = \frac{x}{a-x} \Rightarrow a = 2x = 2 \times 2.5 = 5$

$\Rightarrow (NO + NO_2)_{initial} = a + a = 2a = 2 \times 5 = 10$

also $[N_2O] = \frac{x}{5} = 0.5$

$x = 2.5$

EXERCISE - JEE (Main) PYQ

1. Ans. (4)

A and B

Slop for given group $= -\frac{\Delta H}{R}$ for exothermic slope of group will be positive.

2. Ans. (1)

On increasing volume, reaction move in that direction where more gaseous moles are produced.

3. Ans. (4)

$2NO_2(g) \rightleftharpoons N_2O_4(g)$ is exothermic.

So, $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ is endothermic.

On addition of inert gas at constant pressure, reaction move in that direction where gaseous moles are produced more.

4. Ans. (1)

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

5. Ans. (3)

	$A(s)$	$\rightleftharpoons$	$B(g)$	+	$C(g)$	$K_{P_1} = x\ atm^2$
At equilibrium			P_1		$P_1 + P_2$	
	$D(s)$	$\rightleftharpoons$	$C(g)$	+	$E(g)$	$K_{P_2} = y\ atm^2$
At equilibrium			$P_1 + P_2$		P_2	

$(P_1)(P_1 + P_2) = x$ ...(1)

$(P_2)(P_1 + P_2) = y$ ...(2)

Add equation (1) & (2)

$(P_1 + P_2)^2 = x + y$

$P_1 + P_2 = \sqrt{x + y}$

Total pressure $= P_1 + P_2 + P_1 + P_2$

$= 2(P_1 + P_2) = 2\sqrt{x + y}$ atm.

6. Ans. (2)

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

$2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$ $\quad \frac{1}{K_P}$

$P_1 \quad 3P_1$

$P_1 + 3P_1 = P$

$P_1 = \frac{P}{4}$

$\frac{1}{K_P} = \frac{(P_1)(3P_1)^3}{(P_{NH_3})^2}$

$(P_{NH_3})^2 = K_P \times 27 \times (P_1)^4$

$= 27\ K_P \times \left(\frac{P}{4}\right)^4$

$P_{NH_3} = \frac{3^{\frac{3}{2}} K_P^{\frac{1}{2}} P^2}{16}$

7. Ans. (1)

$\Delta H^o > 0$ T↓ equation shifts back ward.

N_2 is treated as inert gas in this case hence no effect on equilibrium.

8. Ans. (5)

$Cl_2 \rightleftharpoons 2Cl$

Let mol of both of Cl_2 and Cl is x

$$P_{Cl} = \frac{x}{2x} \times 1 = \frac{1}{2}$$

$$P_{Cl_2} = \frac{x}{2x} \times 1 = \frac{1}{2}$$

$$K_p = \frac{\left(\frac{1}{2}\right)^2}{\frac{1}{2}} = \frac{1}{2} = 0.5 \Rightarrow 5 \times 10^{-1}$$

9. Ans. (6)

Moles of NH_4HS initially taken = $\frac{5.1g}{51g/mol}$

= 0.1 mol

volume of vessel = 2ℓ

$$NH_4HS_{(s)} \rightleftharpoons NH_6(g) + H_2S(g)$$

t = 0 0.1 mol

t = ∞ 0.1(1–0.2) 0.1×0.2 0.1×0.2

⇒ partial pressure of each component

$$P = \frac{nRT}{V} = \frac{0.1 \times 0.2 \times 0.082 \times 300}{2}$$

= 0.246 atm

$$\Rightarrow k_P = P_{NH_3} \times P_{H_2S} = (0.246)^2 = 0.060516$$

$= 6.05 \times 10^{-2}$

⇒ 6

10. Ans. (2)

$$K'_{eq} = \frac{1}{\sqrt{K_{eq}}} = \frac{1}{\sqrt{2 \times 10^{15}}} = x \times 10^{-8}$$

$$\Rightarrow \frac{1}{\sqrt{20}} \times \frac{1}{10^7} = x \times 10^{-8} \quad \Rightarrow \frac{1}{\sqrt{20}} \times 10^{-7} = x \times 10^{-8}$$

$$\frac{10}{\sqrt{20}} = x \quad \Rightarrow x = \frac{\sqrt{10}}{\sqrt{2}} = \sqrt{5} = 2.236$$

= 2.24

11. Ans. (2)

2NO	+	O_2	→	2NO
2		1		–
2-2x		1-x		2x
1.2		0.6		0.8

$(n_{total})_{eq} = 1.2 + 0.6 + 0.8 \Rightarrow 2.6$

Partial presence = mole fraction × $(P_{total})_{eq}$

$$K_p = \frac{\left(\frac{0.8}{2.6}\right)^2}{\left(\frac{1.2}{2.6}\right)^2\left(\frac{0.6}{2.6}\right)} = 1.925$$

12. Ans. (20)

$\Delta G° = -RT\ \ell n\ K_{eq}$

Given $\Delta G° = -9.478$ KJ/mole

T = 495K R = 8.314 J mol^{-1}

So $-9.478 \times 10^3 = -495 \times 8.314 \times \ell n\ K_{eq}$

$\ell n\ K_{eq} = 2.303$

$= \ell n\ 10$

So $K_{eq} = 10$

Now $A(g) \rightleftharpoons B(g)$

t = 0 22 0

t = t 22–x x

$$K_{eq} = \frac{[B]}{[C]} = \frac{x}{22-x} = 10$$

or x = 20

So millimoles of B = 20

13. Ans. (354)

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$; $\Delta n_g = 2 - 1 = 1$

Now, $K_p = K_c . (RT)^{\Delta ng}$

or, $600.1 = 20.4 \times (0.0831 \times T)^1$

$\therefore$ T = 353.99 K = 354K

14. Ans. (172)

$2SO_{2(g)} + O_{2(g)} = 2SO_{3(g)}$

$$K_p = \frac{(pSO_{3(g)})^2}{pSO2(g)} \times pO_{2(g)}$$

$= \frac{43 \times 43}{45 \times 45} \times 530\ Pa^{-1}$

$= 172.28 \times 10^{-5}\ Pa^{-1}$

$= 172.28$ atm

$= 17228 \times 10^{-2}$ atm

Ans is 17228

15. Ans. (2)

$A(g) \rightleftharpoons B(g) + \frac{1}{2} C(g)$

Initial : P_i 0 0

At eq.: $P_i(1-\alpha)$ $P_i.\alpha$ $P_i\frac{\alpha}{2}$

Now, equilibrium pressure (p) ,

$P = P_i \times \left(1+\frac{\alpha}{2}\right)$

$\therefore\ P_A = \left(\frac{1-\alpha}{1+\frac{\alpha}{2}}\right)P$

$P_B = \left(\frac{\alpha}{1+\frac{\alpha}{2}}\right)P$

$P_C = \left(\frac{\frac{\alpha}{2}}{1+\frac{\alpha}{2}}\right)P$

$\therefore K = \frac{P_c^{\frac{1}{2}} \times P_B}{P_A}$

$K = \frac{\alpha^{\frac{3}{2}} p^{\frac{1}{2}}}{(2+\alpha)^{\frac{1}{2}}(1-\alpha)}$

16. Ans. (2)

$H_2O(g) \rightleftharpoons H_2(g) + \frac{1}{2} O_2(g)$

$P_0[1-\alpha]$ $P_0\alpha$ $\frac{P_0\alpha}{2}$ partial pr. at eq.

$P_0\left[1+\frac{\alpha}{2}\right] = 1$ ...(i)

$$K_p = \frac{\left(P_{H_2}\right)\left(P_{O_2}\right)^{1/2}}{P_{H_2O}}$$

$$\frac{(P_0\alpha)\left(\frac{P_0\alpha}{2}\right)^{1/2}}{P_0[1-\alpha]} = 2\times10^{-3}$$

since α is negligible w.r.t 1 so $P_0 = 1$ and $1 - \alpha \approx 1$

$$\frac{\alpha\sqrt{\alpha}}{\sqrt{2}} = 2\times10^{-3}$$

$\alpha^{3/2} = 2^{3/2} \times 10^{-3}$

$\alpha = 2^{3/2\times2/3} \times 10^{-3\times2/3}$

$\alpha = 2 \times 10^{-2}$

$\% \alpha = 2\%$

17. Ans. (4)

$$N_2(g)+3H_2(g)\rightleftharpoons 2NH_3(g); \qquad K_1 = 4\times10^5 \qquad ...(i)$$

$$N_2(g)+O_2(g)\rightleftharpoons 2NO(g); \qquad K_2 = 1.6\times10^{12} \qquad ...(ii)$$

$$H_2(g)+\frac{1}{2}O_2(g)\rightleftharpoons H_2O(g); \qquad K_3 = 1.0\times10^{-13} \qquad ...(iii)$$

(ii) + 3 × (iii) – (i)

$$2NH_3(g)+\frac{5}{2}O_2(g)\rightleftharpoons 2NO(g)+3H_2O(g)$$

$$k_{eq} = \frac{k_2\times k_3^3}{k_1} = \frac{1.6\times10^{12}\times(10^{-13})^3}{4\times10^5}$$

$$= \frac{1.6}{4}\times10^{-32} = 4\times10^{-33}$$

18. Ans. (3)

The yield of SO_3 at equilibrium will be due to :

B. Increasing pressure

C. Adding more SO_2

D. Adding more O_2

19. Ans. (12)

	$x(g)$	$\rightleftharpoons$	$y(g)$	+	$z(g)$;	$k_{p_1} = 3$
Initial moles	n		–		–	
at equilibrium	$n - \alpha n$		αn		αn	

$$k_{p_1} = \frac{\left(\frac{\alpha}{1+\alpha}\times p_1\right)^2}{\frac{1-\alpha}{1+\alpha}p_1}$$

$$3 = \frac{\alpha^2\times p_1}{1-\alpha^2}$$

	A(g)	$\rightleftharpoons$	2B(g);	$k_{p_2}=1$
Initial moles	n		–	
at equilibrium	x – αn		2 αn	$p_{total} = p_2$

$$k_{p_2}=\frac{\left(\frac{2\alpha}{1+\alpha}\times p_2\right)^2}{\frac{1-\alpha}{1+\alpha}\times p_2}$$

$$1=\frac{4\alpha^2\times p_2}{1-\alpha^2}$$

$$\frac{k_{p_1}}{k_{p_2}}=\frac{p_1}{4p_2}$$

$\frac{3}{1}=\frac{p_1}{4p_2}$ $\therefore$ $p_1 : p_2 = 12 : 1$

x = 12

20. Ans. (49)

	PCl_3	+	Cl_2	$\rightleftharpoons$	PCl_5
	0.2M		(0.1+0.2)M		0.4M
Eqm.	0.2–x		0.3–x		0.4+x

$$\frac{(0.4+x)}{(0.2-x)(0.3-x)}=20$$

$\Rightarrow x \simeq 0.086$

$[PCl_5]_{eq} = 0.486M = 48.6\times10^{-2}M$

EXERCISE - JEE (Advanced) PYQ

1. Ans. (A, B, D)

(A) The expression for the enthalpy change is $\Delta H = C_P\Delta T$
Hence, the enthalpy of the reaction is temperature-dependent.

(B) Equilibrium constant, K is independent of initial amount of calcium carbonate and is dependent only on temperature.

(C) Equilibrium constant depends on temperature but it is independent of pressure.

(D) Presence of catalyst lowers the activation energy but, the enthalpy of reaction is not affected.

2. Ans. (8.92 or 8.93)

	$Fe^{2\oplus}(aq)$ +	$S^{2\ominus}(aq)$	$\rightleftharpoons$	$FeS(s)$	$K_C = 1.6\times10^{17}$
Initial	0.03 m	0.1 m			
Final	x	(0.1 – 0.03) = 0.07			

Reaction will be almost completed as K_C is very large.

So, $1.6\times10^{17}=\frac{1}{x\times0.07}$

$x = 8.928\times10^{-17} = Y\times10^{-17}$

y = 8.928

3. Ans. (8)

At T_1 K : $A(g) \rightleftharpoons P(g)$

t = 0 6

t = ∞ 6 – x x = 4 (from plot)

$\Rightarrow$ At T_1 K : $K_{P_1} = \frac{4}{2} = 2$

At T_2 K : $A(g) \rightleftharpoons P(g)$

t = 0 6

t = ∞ 6 – y y = 2 (from plot)

$\Rightarrow$ At T_2 K : $K_{P_2} = \frac{2}{4} = \frac{1}{2}$

Now, $\Delta G_2^o = -RT_2 \, ln \, K_{P_2} = -RT_2 \, ln \, \frac{1}{2}$

$\Rightarrow$ $\Delta G_2^o = RT_2 \, ln \, 2$

$\Delta G_1^o = -RT_1 \, ln \, K_{P_1} = -RT_1 \, ln \, 2 = -2RT_2 \, ln \, 2$

Given : $\Delta G_2^o - \Delta G_1^o = RT_2 \, ln \, 2 + 2RT_2 \, ln \, 2 = 3RT_2 \, ln \, 2 = RT_2 \, ln \, x$

$\Rightarrow$ $x = 2^3 = 8$

JEE (Main) Practice Paper

1. Ans. (4)

From definition of chemical equilibrium, rate of forward reaction = rate of backward reaction.

2. Ans. (3)

From question

$K_1 = \frac{[CO_2][H_2]}{[CO][H_2O]}$

$K_2 = \frac{[CO][H_2]^3}{[CH_4][H_2O]}$

$K_3 = \frac{[CO_2][H_2]^4}{[CH_4][H_2O]^2}$

Now check each option.

As for option C.

$K_1 \times K_2 = K_3$

$K_1 \times K_2 = \frac{[CO_2][H_2]}{[CO][H_2O]} \times \frac{[CO][H_2]^3}{[CH_4][H_2O]} = K_3$

3. Ans. (3)

$K_{eq.} = \frac{K_f}{K_b}$

$1.5 = \frac{K_f}{7.5\times10^{-4}}$

$K_f = 1.125 \times 10^{-3}$

4. Ans. (3)

$K_P = K_C(RT)^{\Delta n_g}$; $\Delta n_g = 0$ $K_P = K_C$

(1) $2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$; $\Delta n_g = 1$

(2) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$; $\Delta n_g = -2$

(3) $H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$; $\Delta n_g = 0$

(4) $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$; $\Delta n_g = -1$

5. Ans. (2)

$\log\frac{K_P}{K_C} + \log RT = 0$

$\log\frac{K_P}{K_C} = -\log RT$

$\log\frac{K_P}{K_C} = \log(RT)^{-1}$

$K_P = K_C(RT)^{-1}$

So, Δn_g should be –1.

(1) $PCl_5 \rightleftharpoons PCl_3 + Cl_2 \Rightarrow \Delta n_g = 1$

(2) $2SO_2 + O_2 \rightleftharpoons 2SO_3 \Rightarrow \Delta n_g = -1$

(3) $N_2 + 3H_2 \rightleftharpoons 2NH_3 \Rightarrow \Delta n_g = -2$

6. Ans. (4)

$CuSO_4.5H_2O(s) \rightleftharpoons CuSO_4.3H_2O(s) + 2H_2O(g)$

$K_P = (P_{H_2O})^2$

$K_C = [H_2O]^2$

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

$\Delta n_g = 2$

$K_P = K_C(RT)^2$

7. Ans. (3)

K_C depends only on temperature.

8. Ans. (3)

$\alpha = \frac{\text{moles dissociated}}{\text{initial moles}}$

$\alpha = \frac{0.5}{2} = 0.25$

9. **Ans. (1)**

$2CO_2(g) \rightleftharpoons 2CO(g) + O_2(g)$

Initial	2		
Final	$2(1-\alpha)$	2α	α

Total moles = $2 - 2\alpha + 2\alpha + \alpha = 2 + \alpha$

$\alpha = \frac{40}{100} = 0.4$

Total moles = 2.4

10. **Ans. (3)**

$PCl_5 \rightleftharpoons PCl_3 + Cl_2$

$K_P = \frac{P_{PCl_3}.P_{Cl_2}}{P_{PCl_5}}$

$K_P = \frac{0.3\times0.2}{0.6} = 0.1$

$(K_P) = \frac{2\times0.3\times2\times0.2}{P_{PCl_5}} = 0.1$

$P_{PCl_5} = 2.4$

11. **Ans. (1)**

	H_2	+	I_2	$\rightleftharpoons$	$2HI$
$t = t_{eq.}$	$(0.5 - x)$		$(0.5-x)$		$2x$

$K_C = 49 = \frac{[HI]^2}{[H_2][I_2]}$

Or $7^2 = \frac{[HI]^2}{[H_2][I_2]}$

$\because \quad [H_2] = [I_2]$

$\therefore \quad 7^2 = \frac{[HI]^2}{[I_2]^2}$

$\therefore \quad \frac{[HI]}{[I_2]} = 7$

12. **Ans. (2)**

	A	+	2B	$\rightleftharpoons$	2C	+	D
Initial	a		1.5 a				
At equilibrium	a – x		1.5a – 2x		2x		x

According to problem,

$a - x = x$

$x = \frac{a}{2}$

Concentration of B at equilibrium

$= 1.5a - 2 \times \frac{a}{2} = \frac{a}{2}$

13. Ans. (2)

On reducing pressure, reaction moves in that direction where gaseous moles are produced more.

14. Ans. (3)

	A_2	$\rightleftharpoons$	B_2	+	C_2	$K_P = 9$
t = 0 mole	1					
t = α	1 – α		α		α	$1_{total} = 7$ atm

$$P_{B_2} = P_{C_2} = \frac{\alpha}{1+\alpha} \times 7$$

$$P_{A_2} = \frac{1-\alpha}{1+\alpha} \times 7$$

$$K_P = \frac{\left(\frac{\alpha}{1+\alpha} \times 7\right)^2}{\left(\frac{1-\alpha}{1+\alpha} \times 7\right)} = 9$$

$$\frac{\alpha^2}{1-\alpha^2} \times 7 = 9$$

$7\alpha^2 = 9 - 9\alpha^2$

$16\alpha^2 = 9$

$$\alpha = \frac{3}{4} = \frac{M_T - M_0}{M_0(n-1)}$$

$$\frac{3}{4} = \frac{70 - M_0}{M_0(2-1)}$$

$3M_0 = 280 - 4M_0$

$7M_0 = 280$

$M_0 = 40$

15. Ans. (2)

If product is removed, reaction moves in forward direction.

16. Ans. (3)

Addition of inert gas at equilibrium doesn't have any impact on equilibrium.

17. Ans. (3)

$CO_2(s) \rightleftharpoons CO_2(g)$ $\quad \Delta H$ = +ve

If temperature increases reaction will move in forward direction at it is endothermic reaction.

18. Ans. (3)

	$2NH_{3(g)}$	$\rightleftharpoons$	$N_{2(g)}$	+	$3H_{2(g)}$
1 mol = 17 gm					
	1 – 2α		α		3α

$$M_{av} = \frac{17}{1+2\alpha} = 12 \qquad [VD]_{mix} \times 2 = M_{av}$$

$$\alpha = \frac{5}{24}$$

$$\%\ \text{dissociation} = \frac{2\alpha}{1} \times 100 = 2 \times \frac{5}{24} \times 100 = 41.66\%$$

19. **Ans. (1)**

If $\Delta n_g = 0$, it does not have any effect

20. **Ans. (3)**

If total pressure decreases reaction shifts where gaseous moles are produced more.

SECTION-B

1. **Ans. (16)**

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

t = 0	5	0	0
$t = t_{eq.}$	5 –4 = 1	4	2

$$K_C = \frac{[SO_2]^2[O_2]}{[SO_3]_2}$$

V = 2 litre

$$K_C = \frac{\left(\frac{4}{2}\right)^2\left(\frac{2}{2}\right)^1}{\left(\frac{1}{2}\right)^2}$$

$K_C = 16$

2. **Ans. (3)**

$$K_C = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

$$0.29 = \frac{[NH_3]^2}{(0.036)\times(0.15)^3}$$

$(NH_3) = 5.9 \times 10^{-3}$

y = 3

3. **Ans. (50)**

$$K_P = \frac{4\alpha^2}{1-\alpha^2} \times P_T$$

$$0.667 = \frac{4\alpha^2}{1-\alpha^2} \times \frac{1}{2} \qquad \left(P_T = \frac{380}{760}\text{atm} = \frac{1}{2}\text{atm}\right)$$

$$\frac{\alpha^2}{1-\alpha^2} = \frac{1}{3}$$

$\alpha = 0.5$

% dissociation = 50%

4. **Ans. (1)**

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

$$K_P = \frac{\alpha^2}{1-\alpha^2} \times P_T$$

At $P_T = 4$ atm, $\alpha = 0.1$

$$K_P = \frac{(0.1)^2}{1-(0.1)^2} \times 4$$

So, $$\frac{0.01}{0.99} \times 4 = \frac{(0.2)^2}{1-(0.2)^2} \times P_T$$

$$\frac{4}{99} = \frac{P_T}{24}$$

$$P_T = \frac{96}{99}\text{atm} = 0.97 \text{ atm} \approx 1.00 \text{ atm}$$

5. Ans. (2)

	$C(s)$	+	$CO_2(g)$	$\rightleftharpoons$	$2CO(g)$
Initial			0.5		
Final			0.5 – x		2x

According to problem,

$0.5 - x + 2x = 0.8$

$x = 0.3$

$K_P = \frac{(2x)^2}{0.5-x} = \frac{4x^2}{0.5-x}$

$= \frac{4\times(0.3)^2}{0.2} =$ 1.8 atm $\approx$ 2 atm.

6. Ans. (53)

$N_2O_4 \rightleftharpoons 2NO_2$

$\frac{(V.D.)_i}{(V.D.)_f} = 1 + (n-1)\alpha$

$n = 2$

$\frac{46}{30} = 1 + \alpha$

$\alpha = \frac{16}{30}$

$\%\alpha = 53.33\% \approx 53\%$

7. Ans. (1)

	$NH_2COONH_4(s) \rightleftharpoons 2NH_3(g)$	+	$CO_2(g)$
Initial	2P		P

$K_p = (p_{NH_3})^2(p_{CO_2})$

$K_p = (2P)^2(P)$ ...(i)

Now, in the second case, P_t (initial) = 3P

	$NH_2COONH_4(s) \rightleftharpoons 2NH_3(g)$	+	$CO_2(g)$
Initial	3P		P'

$K_p = (3P)^2(P')$ ...(ii)

From (i) and (ii)

$(2P)^2(P) = (3P)^2(P')$

$P' = \frac{4P}{9}$

$\frac{P_T(new)}{P_T(old)} = \frac{3P+P'}{3P} = \frac{3P+\frac{4P}{9}}{3P} = \frac{31}{27} = 1.14 \approx 1$

8. Ans. (1)

	$A(g)$	+	$B(g)$	$\rightleftharpoons$	$C(g)$	+	$D(g)$
$t = t_{eq.}$	4		4		2		8

$K_{eq} = \frac{[C][D]}{[A][B]}$

$K_{eq} = \frac{2\times8}{4\times4} = 1$

Now, 18 mole of D added, reaction backward

t = t' 4 + x 4 + x 2 – x 8 + 18 – x

But K_{eq} remains same since it is temperature dependent

$1 = \frac{(2-x)(26-x)}{(4+x)^2}$

$16 + x^2 + 8x = 52 - 28x + x^2$

$36\,x = 36 \Rightarrow x = 1$

So, [A] = 5, [B] = 5, [C] = 1, [D] = 25

9. Ans. (50)

Initial number of moles of N_2O_4 are 0.5 mol.

Out of this 79.3% decompose.

Moles of N_2O_4 decomposed = $0.5 \times \frac{79.3}{100} = 0.3965$ moles

The number of moles of N_2O_4 that remains at equilibrium are 0.5 – 0.3965 = 0.1035 moles.

The number of moles of NO_2 formed at equilibrium are 2 × 0.3965 = 0.793.

The equilibrium constant expression is $K_C = \frac{[NO_2]^2}{[N_2O_4]} = \frac{\left(\frac{0.793}{4}\right)^2}{\frac{0.1035}{4}} = 1.51$

The relationship between K_p and K_C is, $K_p = K_c(RT)^{\Delta n}$

For the given reaction, Δn = 2 – 1 = 1

Hence, $K_p = 1.51(0.0821\times405)^1 = 50.20 \approx 50$

10. Ans. (1)

Moles of $CaCO_3 = \frac{20}{100} = 0.2$

	$CaCO_3(s)$	$\rightleftharpoons$	$CaO(s)$	+	$CO_2(g)$
Initial	0.2 moles				

%decomposed = 75%

Moles of $CaCO_3$ decomposed = $\frac{75}{100} \times 0.2 = 0.15$

	$CaCO_3(s)$	$\rightleftharpoons$	$CaO(s)$	+	$CO_2(g)$
At equilibrium	0.05 moles		0.15 moles		0.15 moles

$K_p = p_{CO_2} = \frac{nRT}{V}$

$= \frac{0.15\times0.0821\times1000}{15} = 0.821$ atm ≈ 1.00 atm

JEE (Advanced) Practice Paper

1. Ans. (C)

$BaO_2(s) \rightleftharpoons 2BaO(s) + O_2(g)$

ΔH = +ve → Endothermic

If temperature is increased, then reaction moves in forward direction and pressure will increase.

2. Ans. (C)

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

$2NH_3 \rightleftharpoons N_2 + 3H_2 \ldots\ldots\ldots \frac{1}{K_1}$ ...(1)

$N_2 + O_2 \rightleftharpoons 2NO \ldots\ldots\ldots K_2$ ...(2)

$H_2 + \frac{1}{2}O_2 \rightleftharpoons H_2O \ldots\ldots\ldots K_3$ ...(3)

Multiplying equation (3) by 3

$3H_2 + \frac{3}{2}O_2 \rightleftharpoons 3H_2O \longrightarrow K_3^3$ ...(4)

Adding (1), (2) and (4) we get the desired reaction

$2NH_3 + \frac{5}{2}O_2 \rightleftharpoons 2NO + 3H_2O$

$K_f = \frac{K_2.K_3^3}{K_1}$

3. Ans. (B)

$C_2H_5OH(\ell) + CH_3COOH(\ell) \rightleftharpoons CH_3COOC_2H_2\ (\ell) + H_2O(\ell)$

a	a		
$a-\frac{a}{3}$	$a-\frac{a}{3}$	$\frac{a}{3}$	$\frac{a}{3}$
$\frac{2a}{3}$	$\frac{2a}{3}$	$\frac{a}{3}$	$\frac{a}{3}$

$K_C = \frac{\frac{a}{3}\times\frac{a}{3}}{\frac{2a}{3}\times\frac{2a}{3}}$

$K_C = \frac{1}{4}$

4. Ans. (C)

$HgO(s) + 4I^{\ominus}(aq.) + H_2O(\ell) \rightleftharpoons HgI_4^{2\ominus}(aq.) + 2OH^{\ominus}(aq.)$

$K = \frac{[HgI_4^{2\ominus}][OH]^2}{[I^{\ominus}]^4}$

Reaction required to be shift in forward direction.

If $[I^{\ominus}]$ increases, the reaction shifts in forward direction.

Adding 0.2 M HCl will consume $OH^{\ominus}$ ions from product side.

So, reaction will shift in forward direction.

5. Ans. (ABCD)

As pressure increases equilibrium shift towards left, boiling point also increases and stream gets easily liquefy. Decrease in pressure shifts the equilibrium towards right.

6. Ans. (ACD)

Low pressure and high temperature favours the reaction with $\Delta n_g > 0$ & $\Delta H > 0$

7. Ans. (A)

$K_P = Ae^{-\frac{\Delta H}{RT}}$

$\ell nK_P = \ell n\, A - \frac{\Delta H}{RT}$

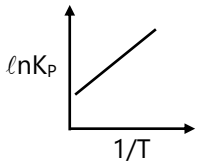
$\downarrow \quad \downarrow \quad \downarrow$

$y \quad c \quad mx$

$m = -\frac{\Delta H}{R}$

reaction is exothermic ΔH = – ve

m = +ve



8. Ans. (ABCD)

If addition of inert gas takes place at constant volume, equilibrium remain undisturbed.

9. Ans. (A)

(1) $2X(g) \rightleftharpoons Y(g) + Z(g)$

1 – –

$1-\alpha \quad \frac{\alpha}{2} \quad \frac{\alpha}{2}$

$K_C = \frac{\frac{\alpha}{2}\times\frac{\alpha}{2}}{(1-\alpha)^2}$ $\alpha \ll 1$

$K_C = \frac{\alpha^2}{4}$ $\alpha = 2\sqrt{K_C}$

$1 \rightarrow$ (p)

(2) $X(g) \rightleftharpoons Y(g) + Z(g)$

1 – –

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

$1 \gg \alpha$ $K_C = \alpha^2$

$1 - \alpha \simeq 1$ $\alpha = \sqrt{K_C}$

$2 \rightarrow$ (s)

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

1 – –

$1-\alpha \quad \frac{\alpha}{3} \quad \frac{\alpha}{3}$

$1 \gg \alpha \qquad K_C = \frac{\alpha^2}{9}$

$1 - \alpha \simeq 1 \qquad \alpha = 3 \times \sqrt{K_C}$

$3 \rightarrow (q)$

(4) $2X(g) \rightleftharpoons Y(g) + 2Z(g)$

1	–	–
$1-\alpha$	$\frac{\alpha}{2}$	α

$1 \gg \alpha \qquad K_C = \alpha^2 \times \frac{\alpha}{2}$

$1 - \alpha \simeq 1 \qquad K_C = \frac{\alpha^3}{2}$

$\alpha = (2K_C)^{1/3}$

$4 \rightarrow (r)$

10. Ans. (B)

For reaction $\Delta_{ng} = 0$ for $H_{2(g)} + I_2(g) \rightleftharpoons 2HI_{(g)}$

$\therefore k_p = k_c (RT)^{\circ}$

$\Rightarrow k_p = k_c = 49$

11. Ans. (C)

	$H_{2(g)}$	+	$I_{2(g)}$	$\rightleftharpoons$	$2HI_{(g)}$
t = 0	0.5 mole		0.5 mole		—
Eq.	(0.5–x)		(0.5-x)		2x

Total moles = (0.5–x) + (0.5–x) + 2x

By PV = nRT

P × 7 = 1 × 0.821 × 700

P = 8.21 atm

12. Ans. (B)

$$K_c = \frac{[HI]^2}{[H_3][I_2]}$$

$$49 = \frac{(2x)^2}{(0.5-x)(0.5-x)} \Rightarrow 7 = \frac{2x}{0.5-x}$$

$$x = \frac{3.5}{9}$$

moles $(I_2) = 0.5 - \frac{3.5}{9} = \frac{1}{9}$

13. Ans. (A)

For HI $\longrightarrow P_{HI} \times V = n_{HI} . RT$

$$P_{HI} \times 7 = \left(2 \times \frac{3.5}{9}\right) \times 0.0821 \times 700$$

$$P_{HI} = \frac{7}{9} \times 8.21 = 6.385 \text{ atm}$$

14. Ans. (D)

As pressure increases, reaction moves backward hence degree of dissociation decreases but k_c remains constant as all equilibrium constant depends only and only on temperature.

15. Ans. (A)

$2SO_2 + O_2 \rightleftharpoons 2SO_3$; Δx = – ve

As temperature increases, for exothermic reaction, reaction moves backward, hence dissociation of SO_3 increases,

For exothermic reaction as temperature increases K_c (equilibrium constant) decreases

16. Ans. (A)

As $Fe^{3\oplus}$ is added in solution, reaction moves forward as per $Le^{\ominus}$ chatelain's principle and red colour of reaction depends due to formation of $\left[Fe(NCS)\right]^{2\oplus}_{(aq.)}$

17. Ans. (8.00)

These will be present in

N_2 NHD_2
H_2 NH_2D
D_2 HD
NH_3
ND_3

} = 8

18. Ans. (4.00)

A(g)	⇌	B(g)	+	C(g)	K_{c_1}
1 – x		x + y		x – y	
C(g)	⇌	D(g)	+	B(g)	K_{c_2}
x – y		y		y + x	

$\frac{x-y}{x+y}=\frac{1}{5}$

$5x - 5y = x + y$

$x=\frac{3y}{2}$

T, V → const.

$P \propto n$

$N_{\text{total equilibrium}} = 2$

$x + y = 1$

$y=\frac{2}{5}, x=\frac{3}{2}$

$\frac{K_{c_1}}{K_{c_2}}=\frac{(x+y)y(1-x)}{(x-y)(x-y)(x+y)}=\frac{(1-x)y}{(x-y)^2}$

$\frac{K_{c_1}}{K_{c_2}} = 4$

19. Ans. (16.00)

	$H_2(g)$	+	$I_2(g)$	⇌	$2HI(g)$
t = 0					4.8×10^{-3} M
t = eq.	$\frac{x}{2}$		$\frac{x}{2}$		$4.8 \times 10^{-3} - x$

$\frac{x}{2} = 8 \times 10^{-4}$

$x = 16 \times 10^{-4}$ M

$[HI] = 32 \times 10^{-4}$ M

$[I_2] = [H_2] = 8 \times 10^{-4}$

$K_C = \frac{(32\times10^{-4})^2}{8\times10^{-4}\times8\times10^{-4}} = \frac{32\times32\times10^{-8}}{64\times10^{-8}} = 16$

20. Ans. (8.00)

$P_B : P_D = 1 : 6$ Let the partial pressure of $B_{eq.}$ be P_0

$K_{P_1} = (P_0)^2 \left(\frac{3P_0}{2}\right)^3$

$K_{P_2} = (6P_0)^3$

$\frac{K_{P_2}}{K_{P_1}} = \frac{6^3}{\left(\frac{3}{2}\right)^3} = 64$

$\frac{K_{P_2}}{8K_{P_1}} = \frac{64}{8} = 8$