## **EXERCISE-01**

SELECT	THE CORRECT ALT	ERNATIVE (ONLY ONE	CORRECT ANSWER)	
1.	In a reaction $\mathrm{PCl}_5 \[\] \oplus \[\] \oplus$	$PCl_3 + Cl_2$ degree of diss	ociation is 30%. If initial m	oles of $\mathrm{PCl}_5$ is one then total
	moles at equilibrium is			
	(A) 1.3	(B) 0.7	(C) 1.6	(D) 1.0
2.	For reaction HI	$\Box$ H <sub>2</sub> + $\Box$ I <sub>2</sub> value of K <sub>c</sub> is	$1/8$ then value of $\rm K_{_c}$ for H	$_{2} + I_{2} \blacksquare \blacksquare \blacksquare 2HI.$
	(A) $\frac{1}{64}$	(B) 64	(C) $\frac{1}{8}$	(D) 8
3.	In a equilibrium reaction	$H_2(g) + I_2(g) = 1$ $HI(g)$	)	
	$\Delta H = -3000$ calories,			
	which factor favours diss	sociation of HI :-		
	(A) Low temp.	(B) High Pressure	(C) High temp.	(D) Low pressure.
4.	$N_2 + 3H_2 = 2NH_3$			
	If temp. of following equ	illibrium reaction increase f	ihen -	
	(A) Shift Right side	(B) Shift left side	(C) Unchanged	(D) Nothing say.
5.	$C(s) + H_2O(g) \square \square \square H$	$I_{2}(g) + CO(g)$		
	by increasing pressure for	ollowing equilibrium		
	(A) Unaffected		(B) Proceed in backward	direction
6	(C) Proceed in forward c	lirection	(D) Untixed	
6.		tant K for following homo	genous reaction :-	
	$4NH_3 + 5O_2 = 2$	$O + 6H_2O$ is		
	(A) (Conc <sup>n</sup> ) <sup>-1</sup>	(B) (Conc <sup>n</sup> ) <sup>+1</sup>	(C) $(Conc^{n})^{+10}$	(D) Have no unit
7.	Which of the following f	actor shifted the reaction P	$PCl_3 + Cl_2 \blacksquare \blacksquare \blacksquare PCl_5 at left $	eft side.
_	(A) Adding PCl <sub>5</sub>	(B) Increase pressure	(C) Constant temp.	(D) Catalyst.
8.	In which of the following	g process reaction is fastes	t complete.	
0	(A) $K = 10$	(B) $K = 1$	(C) $K = 10^3$	(D) $K = 10^{-2}$
9.	At 298 K equilibrium co	instant $K_1$ and $K_2$ of		
	tollowing reaction $SO_2$ (g	$g) + \Box O_2(g) \square \square \square SO_3(g)$	i) (1)	
	$2SO_3(g) = 2SO_2(g)$	+ O <sub>2</sub> (g) (2)		
	The relation between $K_1$	and $K_2$ is		
	(A) $K_1 = K_2$	(B) $K_2 = K_1^2$	(C) $K_2 = 1/K_1^2$	(D) $K_2 = 1/K_1$
10.	In the following reaction P	$\operatorname{Cl}_{5}(g) = \operatorname{PCl}_{3}(g) + \operatorname{Cl}_{2}(g)$	) at constant temp. rate of ba	ckward reaction is increase by :
	(A) Inert gas mixed at co	nstant volume	(B) Cl <sub>2</sub> gas mixed at cons	stant volume
	(C) Inert gas mixed at co	nstant pressure	(D) PCl <sub>5</sub> mixed in consta	nt volume.
11.	Some gaseous equilibriu	m are tollowing :		
	$CO + H_2O = K CO_2$	+ H <sub>2</sub>		
	$2CO + O_2 = 10$	2		
	K.			
	$2H_2 + O_2 = 2H_2O$			
	then find out the relation	n between equilibrium cons	tants :-	
	(A) $K = K_1 K_2$	(B) $K = (K_1 K_2)^2$	$(C) K = (K_1 K_2)^{-\Box}$	(D) $K = (K_1/K_2)^{\square}$

				<u> </u>
12.	For the equilibrium pro	ocess x + y ⊟ ⊡∰ xy. If th	he conc <sup>n</sup> . of x and y is do	ubled, then equilibrium constant.
10	(A) Become twice	(B) Become half	(C) Unchanged	(D) Become thrice
13.	Two moles of $PCl_5$ we dissociated into $PCl_3$ a	vere heated in closed ves nd Cl <sub>2</sub> . The value of equili	ssel of 2 litre capacity, a brium constant is :	it equilibrium 40% of PCI <sub>5</sub> was
	(A) .267	(B) .53	(C) 2.67	(D) 5.3
14.	The reaction $A(g) + E$	lig) ∏ ⊡ ∰ 2C(g) is occur 1	by mixing of 3 moles of	A and 1 mole of B in one litre
	Container. if $\alpha$ of B is	$\frac{1}{3}$ , then $K_c$ for this reacti	on is :-	
	(A) 0.12	(B) 0.25	(C) 0.50	(D) 0.75
15.	Reaction $2BaO_2(s)$ $\square$ and $\square$	$2BaO(s) + O_2(g);$	$\Delta H = + ve.$ At equilibri	ium condition, Pressure of $\mathrm{O}_{\mathrm{2}}$ is
	(A) Increase mass of B	aO <sub>2</sub>	(B) Increase mass of	BaO
	(C) Increase temp. at I	Eq <sup>m</sup> .	(D) Increase mass of	${\rm BaO}_{_2}$ and ${\rm BaO}$ both
16.	Consider the following the volume of the reac regarding the equilibri	g equilibrium in a closed co tion container is halved. Fo um constant (K <sub>p</sub> ) and degre	ontainer $N_2O_4(g) \blacksquare \oplus \textcircled{m} 2$ or this change, which of the ee of dissociation ( $\alpha$ ) :-	$\mathrm{NO}_2$ (g). At a fixed temperature, he following statements held true
	(A) Neither $K_{p}^{}$ nor $\alpha$ c	hanges	(B) Both $K_{_p}$ and $\alpha$ - c	hanges
	(C) $K_{_p}$ changes, but $\alpha$	does not change	(D) $ m K_{p}$ does not char	nge, but $\alpha$ - changes
17.	$C(s) + CO_2(g)$	2CO(g)		
	According to above re above reaction :-	action, partial Pressure of	CO <sub>2</sub> & CO are 4 & 8 re	spectively then find out $K_{_{\rm p}}$ of the
	(A) 6	(B) 2	(C) 16	(D) 32
18.	For the reaction, A+B equilibrium is :-	$C + D, K_c = 9.$ If	A and B are taken in equ	al amounts, then amount of C at
	(A) 1	(B) 0.25	(C) 0.75	(D) None of these
19.	At equilibrium 500ml then what would be	_ vessel contains 1.5 M the K <sub>c</sub> :-	of each A, B, C, D. If	0.5M of C and D expelled out
	(A) 1	$(\mathbf{P}) = \frac{1}{2}$	$(C) \frac{4}{4}$	$(D) \frac{5}{5}$
		(D) $\frac{1}{9}$	$(C) \frac{1}{9}$	$\frac{(D)}{9}$
20.	The following equilibri	um are given		
	$N_2 + 3H_2 = 2NH$	H <sub>3</sub> K <sub>1</sub>		
	$N_2 + O_2 = 1$ 2NO	K <sub>2</sub>		
	$H_2 + \frac{1}{2}O_2 \blacksquare \Box \blacksquare H_2$	O K <sub>3</sub>		
	The equilibrium consta	ant of the reaction		
	$2\mathrm{NH}_3 + \frac{5}{2}\mathrm{O}_2 = 100$	2NO + 3 $H_2O$ , in terms of	of $K_1^{}, K_2^{}$ and $K_3^{}$ is :	
	(A) $\frac{K_1K_2}{K_3}$	(B) $\frac{K_1 K_3^2}{K_2}$	(C) $\frac{K_2 K_3^3}{K_1}$	(D) $K_1 K_2 K_3$
21.	The reaction $A + B \in A$ was 3n and that of to the equal	□ ⊕ ⊕ C + D is studied in B was n. When equilibrium puilibrium concentration o	a one litre vessel at 250 n was attained, equilibriu f B. What is the concen	D°C. The initial concentration of m concentration of C was found tration of D at equilibrium :

(A) n/2 (B) (3n - 1/2) (C) (n - n/3) (D) n

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22.	In a reversible reaction $A = \bigoplus_{k_2}^{k_1} B$ , the initial concentration of A and B are a and b in moles per litre and				
	the equilibrium concentra	tion are (a – x) and (b + x	) respectively ; express x i	in terms of $k_1^{}, k_2^{}, a$ and $b$ :	
	(A) $\frac{k_1 a - k_2 b}{k_1 + k_2}$	(B) $\frac{k_1 a - k_2 b}{k_1 - k_2}$	(C) $\frac{k_1 a - k_2 b}{k_1 k_2}$	(D) $\frac{k_1 a + k_2 b}{k_1 + k_2}$	
23.	The value of $K_{\!_{\rm p}}$ for the	reaction			
	$2H_2O$ (g) + $2Cl_2O$ (g)	$1 \oplus 1 \oplus$	)		
	is 0.03 atm at $427^{\circ}$ C, we the same reaction is :	when the partial pressure a	are expressed in atmosphe	ere then the value of $\rm K_{\rm c}$ for	
	(A) 5.23 Y 10 <sup>-4</sup>	(B) 7.34 Y 10 <sup>-4</sup>	(C) 3.2 Y 10 <sup>-3</sup>	(D) 5.43 Y 10 <sup>-5</sup>	
24.	The equilibrium constant	of the reaction $SO_2(g) + \frac{1}{2}G$	$O_2(g) \equiv \Box = SO_3(g)$ is 4 Y	$10^{-3}$ atm <sup>-1/2</sup> . The equilibrium	
	constant of the reaction	$2 \text{ SO}_3$ (g) $2 \text{ SO}_2$ (g)	g) + $O_2$ (g) would be :		
	(A) 250 atm	(B) 4 4 10 <sup>3</sup> atm	(C) 0.25 4 10 <sup>4</sup> atm	(D) 6.25 Y 10 <sup>4</sup> atm	
25.	When alcohol ( $C_2H_5OH$ ) into ester. Then the $K_c$ f	and acetic acid are mixed to for the equilibrium :	together in equimolar ratio	o at 27°C, 33% is converted	
	$C_2H_5OH(\ell) + CH_3CO$	OOH (ℓ) 目目 CH <sub>3</sub> COC	$OC_2H_2(\ell) + H_2O(\ell)$		
	(A) 4	(B) 1/4	(C) 9	(D) 1/9	
26.	2 moles each of $SO_3$ , CO is $1/9$ then :	, $\mathrm{SO}_2$ and $\mathrm{CO}_2$ is taken in a	a one lit. vessel. If $K_{\rm C}$ for S0	$O_3 + CO \square \square \square SO_2 + CO_2$	
	(A) total no. of moles at	equilibrium are less than	8		
	(B) n (SO <sub>3</sub> ) + n(CO <sub>2</sub> ) = $\frac{1}{2}$	4			
	(C) $[n(SO_2)/n (CO)] < 1$				
	(D) both (B) and (C)				
27.	An equilibrium mixture in	n a vessel of capacity 100	litre contain 1 mol $N_2$ , 2	mol $O_2$ and 3 mol NO. No.	
	(A) $(101/18)$	(B) (101/9)	(C) $(202/9)$	(D) None of these	
28.	Ammonia gas at 15 atm	is introduced in a rigid ver	ssel at 300 K. At equilibri	um the total pressure of the	
	$(\Delta) \cap G$	$(\mathbf{R}) \cap \mathbf{A}$	(C) unpredictable	(D) none of these	
29.	The degree of dissociation	on of SQ, is α at equilibri	um pressure P.:	(D) none of mese	
	Kn for 2SO (д) ныш	$2SO(\sigma) + O(\sigma)$	<b>p</b>		
	(A) $[(P_{\alpha}\alpha^{3})/2(1 - \alpha)^{3}]$	(B) $[(P_{\alpha}\alpha^{3})/(2 + \alpha)(1-\alpha)^{2}]$	(C) $[(P_{\alpha}\alpha^2)/2(1 - \alpha)^2]$	(D) none of these	
30.	For the reaction $CO(g) + of CO_{1}(g)$ can be increa	$H_2O(g) \oplus H_2O(g) +$	$H_2(g)$ at a given tempera	ture the equilibrium amount	
	(A) adding a suitable cata	alyst	(B) adding an inert gas		
	(C) decreasing the volum	e of container	(D) increasing the amount	nt of CO (g)	
31.	For the reaction :				
	$\operatorname{PCl}_5(g) \to \operatorname{PCl}_3(g) +$	Cl <sub>2</sub> (g)			
	The forward reaction at	constant temperature is fa	avoured by		
	(A) introducing an inert	gas at constant volume	(B) introducing chlorine	gas at constant volume	
	(C) introducing an inert	gas at constant pressure	(D) increasing the volum	e of the container	
	(E) introducing PCl <sub>5</sub> at co	onstant volume			

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32.	Given the following reaction at equilibrium $N_2(g) + 3H_2(g) = 10 - 2 \text{ NH}_3(g)$ . Some inert gas at constant pressure is added to the system. Predict which of the following facts will be affected :			
	(A) more $\mathrm{NH}_3$ (g) is produced	(B) less $\mathrm{NH}_3$ (g) is produced		
	(C) no affect on the equilibrium	(D) $K_p$ of the reaction is decreased		
33.	For an equilibrium $H_2O$ (s) $\square \square \square H_2O$ ( $\ell$ ) which	of the following statement is true :		
	(A) the pressure changes do not affect the equilib	rium		
	(B) more of ice melts if pressure on the system is	increased		
	(C) more of liquid freezes if pressure on the syste	m is increase		
	(D) the pressure changes may increase or decrease upon the temperature of the system.	the degree of advancement of the reaction depending		
34.	When a bottle of cold drink is opened, the gas co	omes out with a fizze due to :		
	(A) decrease in temperature	(B) increase in pressure		
	(C) decrease in pressure suddenly which results in	decrease of solubility of $\mathrm{CO}_{\!_2}\mathrm{gas}$ in water		
	(D) none			
35.	The equilibrium, $SO_2Cl_2(g) \blacksquare \Box \Box$ $SO_2(g) + Cl_2(g)$ gas, helium, is introduced. Which of the following	is attained at 25°C in a closed container and an inert statements are correct :		
	(A) concentrations of $SO_2$ , $Cl_2$ and $SO_2Cl_2$ are characteristic concentrations of $SO_2$ , $Cl_2$ and $SO_2Cl_2$ are characteristic concentrations of $SO_2$ ,	anged		
	(B) no effect on equilibrium			
	(C) concentration of $SO_2$ is reduced			
	(D) $K_{_{\rm p}}$ of reaction is increasing			
36.	For the reaction $\rm H^{}_{2}$ (g) + $\rm I^{}_{2}$ (g) $\exists$ $\exists$ $\textcircled{H}$ $\textcircled{H}$ 2HI (g)			
	$K_{c} = 66.9$ at 350°C and $K_{c} = 50.0$ at 448°C. The	ne reaction has :		
	(A) $\Delta H = +ve$	(B) $\Delta H = -ve$		
	(C) $\Delta H = Zero$	(D) $\Delta H = Not$ found the signs		
37.	Variation of $\log_{10} K$ with $\frac{1}{T}$ is shown by the follow	ing graph in which straight line		
	is at 45°, hence $\Delta H^{\circ}$ is :	log <sub>10</sub> KA		
	(A) +4.606 cal	(B) –4.606 cal		
	(C) 2 cal	(D) – 2cal $1/T \rightarrow$		

		EXERCISE -1
7 8 9	10 11 12	13 14 15
A C C	B D C	A B C
22 23 24	25 26 27	28 29 30
A A D	B D A	B B D
37		
В		
	7         8         9           A         C         C           22         23         24           A         A         D           37         -         -           B         -         -	7         8         9         10         11         12           A         C         C         B         D         C           22         23         24         25         26         27           A         A         D         B         D         A           37                B

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## EXERCISE-02

# BRAIN TEASERS

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SELEC	T THE CORRECT ALTI	ERNATIVES (ONE OR M	IORE THEN ONE COR	RECT ANSWERS)		
1.	Consider following reaction in equilibrium with equilibrium concentration 0.01 M of every species					
	(I) $PCl_5$ (g) $\square \square \square$ $PCl_3$ (g) + $Cl_2$ (g)					
	(II) 2HI (g) 🛛 🖽 H <sub>2</sub> (g	$i) + I_2 (g)$				
	(III)N <sub>2</sub> (g) + 3H <sub>2</sub> (g) 目目	🕀 2NH <sub>3</sub> (g)				
	Extent of the reactions	taking place is :				
	(A) $I > II > III$	(B) I $<$ II $<$ III	(C) II < III < I	(D) III $< I < II$		
2.	For the reaction 3 A (g) of the flask, if a mixture	+ B (g) 🗄 н 👘 2 C (g) at a e of 2.0 mol each of A, B	given temperature, $K_c = 9$ 3 and C exist in equilibriu	.0. What must be the volume m?		
	(A) 6 L	(B) 9 L	(C) 36 L	(D) None of these		
3.	Sulphide ion in alkaline $S_2^{2^-}$ , $S_3^{2^-}$ , $S_{4^-}^{2^-}$ and so or of $S_3^{2^-}$ is 132 (K <sub>2</sub> ), both $S_2^{2^-}$ and S ?	e solution reacts with solid n. The equilibrium constant a from S and S <sup>2-</sup> . What is t	d sulphur to form polysul t for the formation of $S_2^{2^-}$ is the equilibrium constant fo	phide ions having formulae s 12 ( $K_1$ ) & for the formation of $S_3^{2-}$ from		
	(A) 11	(B) 12	(C) 132	(D) None of these		
4.	For the following gases	equilibrium	$N_2O_4$ (g) $1 \oplus 1 \oplus 2$ $NO_2$	(g)		
	K <sub>p</sub> is found to be equal (A) 0°C	to K <sub>c</sub> . This is attained wh (B) 273 K	en : (C) 1 K	(D) 12.19 K		
5.	1 mole $N_2$ and 3 mol H 3 atm at the same term	$\rm H_2$ are placed in a closed c perature when the following	ontainer at a pressure of ng equilibrium is attained	4 atm. The pressure falls to		
	$N_{2} (g) + 3H_{2} (g)$	$\textcircled{1}$ 2NH $_3$ (g). The equilibr	ium constant $K_p$ for disso	ciation of $\operatorname{NH}_3$ is :		
	(A) $\frac{1}{0.5} \times (1.5)^3 \text{atm}^{-2}$	(B) 0.5 Y (1.5) <sup>3</sup> atm <sup>2</sup>	(C) $\frac{0.5 \times (1.5)^3}{3 \times 3}$ atm <sup>2</sup>	(D) $\frac{3 \times 3}{0.5 \times (1.5)^3} \text{ atm}^{-2}$		
6.	One mole of $N_2O_4$ (g) a 20% by mass of $N_2O_4$ (	t 300 K is left in a closed g) decomposes to NO <sub>2</sub> (g).	container under one atm. The resultant pressure i	It is heated to 600 K when s :		
	(A) 1.2 atm	(B) 2.4 atm	(C) 2.0 atm	(D) 1.0 atm		
7.	For the reaction : 2 HI (g constant K <sub>2</sub> by the exp	) $\square \square \square$ $H_2(g) + I_2(g)$ , the d ression :	legree of dissociation ( $\alpha$ ) of	Hl (g) is related to equilibrium		
			2K	$2\sqrt{K_{r}}$		
	(A) $\frac{1+2\sqrt{\kappa_{p}}}{2}$	(B) $\sqrt{\frac{1+2R_p}{2}}$	(C) $\sqrt{\frac{2K_{\rm p}}{1+2K_{\rm P}}}$	(D) $\frac{V^{p}}{1+2\sqrt{K_{p}}}$		
8.	The vapour density of 1 temperature :	$N_2O_4$ at a certain tempera	ture is 30. What is the $\%$	dissociation of $\mathrm{N_2O_4}\mathrm{at}$ this		
	(A) 53.3%	(B) 106.6%	(C) 26.7%	(D) None		
9.	For the reaction $PCl_5$ (g) by :	$PCl_3(g) + Cl_2(g), tl$	ne forward reaction at cons	stant temperature is favoured		
	(A) introducing an inert	gas at constant volume				
	(B) introducing chlorine	gas at constant volume				
	(C) introducing an inert	gas at constant pressure				

(D) introducing  $\mathrm{PCl}_{\mathrm{5}}\,\mathrm{at}$  constant volume

10.	When N <sub>2</sub> O <sub>5</sub> is heated	at temp. T, it dissociate	s as $N_2O_5 \square \square N_2O_3$	+ $O_2$ , $K_c = 2.5$ . At the same time
	N <sub>2</sub> O <sub>2</sub> also decomposes	s as : N₂O₂ ⊟⊡⊞ N₂O	$+ O_{2}$ . If initially 4.0 m	oles of $N_2O_5$ are taken in 1.0 litre
	flask and allowed to at	ttain equilibrium, concen	tration of $O_2$ was formed	l to be 2.5 M. Equilibrium concen-
	tration of $N_2O$ is :			
	(A) 1.0	(B) 1.5	(C) 2.166	(D) 0.334
11.	Densities of diamond	and graphite are 3.5 a	nd 2.3 g/mL.	
	C (diamond) $\square \square \square$	C (graphite)	$\Delta_{\rm r} H = -1.9 \ {\rm kJ/m}$	ole
	favourable conditions	for formation of diamo	nd are :	
	(A) high pressure and	low temperature		
	(B) low pressure and	high temperature		
	(C) high pressure and	high temperature		
	(D) low pressure and	low temperature		
12.	When NaNO <sub>3</sub> is heate	ed in a closed vessel, ox	ygen is liberated and Na	NO <sub>2</sub> is left behind. At equilibrium:
	(A) addition of NaNO	, favours reverse reactio	n	-
	(B) addition of NaNO	a favours forward reaction	n	
	(C) increasing temperative	ature favours forward re	action	
	(D) increasing pressur	e favours reverse reactio	n	
13.	The equilibrium SO <sub>2</sub> C	:l <sub>a</sub> (g) 目目冊 SO <sub>a</sub> (g) + (	Cl. (g) is attained at 25°C	C in a closed rigid container when
	an inert gas, helium i	s introduced. Which of	the following statement	is / are correct :
	(A) concentrations of	$SO_2$ , $Cl_2$ and $SO_2Cl_2$ do	not change	
	(B) more chlorine is f	ormed		
	(C) concentration of S	SO <sub>2</sub> is reduced		
	(D) more SO <sub>2</sub> Cl <sub>2</sub> is for	rmed		
14.	For the gas phase rea	action, $C_2H_4 + H_2$	$C_2 H_6 (\Delta H = -32.7 \text{ km})$	cal), carried out in a closed vessel,
	the equilibrium moles	of $C_2H_4$ can be increase	ed by :	
	(A) increasing the terr	perature	(B) decreasing the	pressure
	(C) removing some H	2	(D) adding some (	$C_2H_6$
15.	An exothermic reaction	on is represented by the	graph :	
	<b>↑</b>	Ť	Ť	<b>↑</b> ,
	(A) lnKp	(B) InKp	(C) InK	(D) $lnK_p$
	1/T	1/T	1/T	→ 1/T →
16	The correct relationshi	n hetween free energy ch	ange in a reaction and the	corresponding equilibrium constant
10.	K is :	b between nee energy en		conceptioning equilibrium constant
	(A) $-\Delta G^\circ = RT \ln K$	(B) ∆G = RT <i>l</i> n K	(C) $-\Delta G = RT ln$	K (D) $\Delta G^{\circ} = RT \ln K$
17.	The value of $\Delta G^{\circ}_{f}$ of ga	seous mercury is 31 kJ/1	mole. At what external p	ressure mercury start boiling 25°C.
	[R = 8.3  J/K mole]			
	(A) 10 <sup>-5.44</sup>	(B) 10 <sup>-12.5</sup>	(C) 10 <sup>-6.52</sup>	(D) 10 <sup>-3.12</sup>
18.	What is $\Delta_{r}G$ (kJ/mole	) for synthesis of ammo	nia at 298 K at followir	ng sets of partial pressure :
	N <sub>2</sub> (g) + 3H <sub>2</sub> (g) 目目	$2NH_{3}(g); \Delta_{r}G^{\circ} = -33 \text{ kJ}$	/mole. [Take R = 8.3 J/I	K mole, $\log 2 = 0.3$ ; $\log 3 = 0.48$ ]
	Gas	$N_2$	H <sub>2</sub>	NH <sub>3</sub>
	Pressure (atm)	1	3	0.02
	(A) +6.5	(B) –6.5	(C) +60.5	(D) -60.5
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19.	In a 7.0 L evacuated chamber, 0.50 mol $H_2$ and 0.50 mol $I_2$ react at 427°C.				
	$H_2(g) + I_2(g) = 0.0000000000000000000000000000000000$	I (g). At the given tempe	rature, $K_c = 49$ for the re	eaction.	
(i)	What is the value of $K_p$ ?				
	(A) 7	(B) 49	(C) 24.5	(D) None	
(ii)	What is the total pressure	e (atm) in the chamber ?			
	(A) 83.14	(B) 831.4	(C) 8.21	(D) None	
(iii)	How many moles of the	iodine remain unreacted	at equilibrium ?		
	(A) 0.388	(B) 0.112	(C) 0.25	(D) 0.125	
(iv)	What is the partial press	ure (atm) of HI in the equ	uilibrium mixture?		
	(A) 6.385	(B) 12.77	(C) 40.768	(D) 646.58	
20.	$N_2 + O_2 = 2NO, K$	$I_1$ ; $\left(\frac{1}{2}\right)N_2$ + $\left(\frac{1}{2}\right)O_2$	NO, K <sub>2</sub>		
	$2NO \square \square \square N_2 + O_2, K$	$I_3$ ; NO $I$	$\left(\frac{1}{2}\right)O_2, K_4$		
	Correct relation between	$\textbf{K}_{1},~\textbf{K}_{2},~\textbf{K}_{3}~\text{and}~\textbf{K}_{4}~\text{is}~:$			
	(A) $K_1 H K_3 = 1$	$\textbf{(B)}  \sqrt{K_1} \times K_4 = 1$	(C) $\sqrt{K_3} \times K_2 = 1$	(D) None	
21.	The equation, $a = \frac{D-d}{(n-1)e}$	$\frac{1}{d}$ is correctly matched fo	r :		
	(A) A □ □ □ nB/2 + nC	2/3	(B) A □ □ □ □ nB/3 + (2	n/3)C	
	(C) A $\rightarrow$ (n/2)B + (n/4)C		(D) A □ □ □ (n/2)B + 0	2	

**22.** Variation of equilibrium constant K for the reaction ; 2A(s) + B(g) = C(g) + 2D(g) is plotted against absolute temperature T in figure as - lnK Vs (1/T) :



(A) the forward reaction is exothermic

- (B) the forward reaction is endothermic
- (C) the slope of line is proportional to  $\Delta H$
- (E) removing C favours forward reaction
- (D) adding 'A' favours forward reaction

(D) C(s) +  $H_2O$  (g)  $\square$   $\square$  CO (g) +  $H_2$  (g)

- **23.** The equilibrium of which of the following reactions will not be disturbed by the addition of an inert gas at constant volume?
  - (A)  $H_2$  (g) +  $I_2$  (g)  $\square \square \square$  2HI (g) (B)  $N_2O_4$  (g)  $\square \square \square$  2NO<sub>2</sub> (g)

(C) CO (g) +  $2H_2$  (g)  $\square \square \square$  CH<sub>3</sub>OH (g)

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

C(s) + H<sub>2</sub>O (g)  $\square$   $\square$  CO(g) + H<sub>2</sub>(g),  $\Delta$ H = +131 kJ

The yield of CO and  $\mathrm{H}_{\!_2}$  at equilibrium would be shifted to the product side by

- (A) raising the relative pressure of the steam
- (B) adding hot carbon
- (C) raising the temperature
- (D) reducing the volume of the system

**25.** The dissociation of ammonium carbamate may be represented by the equation :

 $NH_4CO_2NH_2$  (s)  $\square \square \square \square$   $2NH_3$  (g) +  $CO_2$  (g)

 $\Delta H^0$  for the forward reaction is negative. The equilibrium will shift from right to left if there is

- (A) a decrease in pressure
- (B) an increase in temperature
- (C) an increase in the concentration of ammonia
- (D) an increase in the concentration of carbon dioxide
- **26.** The percentage of ammonia obtainable, if equilibrium were to be established during the Haber process, is plotted against the operating pressure for two temperatures 400°C and 500°C. Which of the following correctly represents the two graphs ?



BRAII	N TEAS	SERS					ANS	WER	KEY	7				EXERCIS	SE -2
Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	В	А	А	D	В	В	D	А	C,D	D	С	C,D	А	A,B,C,D	А
Que.	16	17	18	19(i)	(ii)	(iii)	(iv)	20	21	22	23	24	25	26	
Ans.	А	А	D	В	С	В	А	A,B,C	В	A,C,E	A,B,C,D	A,C	B,C,D	А	

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## **EXERCISE-03**

## TRUE / FALSE

- **1**. Van't Hoff's equation gives the quantitative relation between change in value of K with change in temperature.
- 2. The larger value of K indicates that the product is more stable relative to reactants.
- **3**. The value of equilibrium constant changes with change in the initial concentration of the reactants.
- 4. Extent of a reaction can always be increased by increasing the temperature.
- 5.  $K_{\rm P}$  is related to  $K_{\rm C}$  as  $K_{\rm P} = K_{\rm C} (RT)^{\Delta n}$ .
- 6. Introduction of inert gas in a gaseous reaction  $(\Delta n_g \neq 0)$  at equilibrium keeping pressure constant has no effect on equilibrium state.
- 7. For the reaction,  $N_2O_4(g) \equiv 10^{-10} 2NO_2(g)$ ,  $K_p = K_c(RT)$ .
- **8.** For a reaction the value of Q greater than K indicates that the net reaction is proceeding in backward direction.
- 9. Solubilities of all solids in water increase with increase in temperature.
- 10. Dissolution of all gases in water is accompained by evolution of heat.

11. For the reaction, 
$$N_2 + 3H_2 = 10^{-1}$$
  $2NH_3$ , the equilibrium expression may be written as  $K = \frac{[NH_3]^2}{[N_2][H_2]^3}$ .

**12.** For the reaction, 
$$CaCO_3$$
 (s)  $\Box \Box \Box \Box$  CaO (s) +  $CO_2$  (g),  $K_p = p_{CO_2}$ .

- 13. A catalyst increases the value of the equilibrium constant for a reaction.
- 14. If concentration quotient of reaction is less than K, the net reaction is proceeding in the backward direction.
- **15**. In case of endothermic reaction, the equilibrium shifts in backward direction on increasing the temperature.
- **16.** The value of K increases with increase in pressure.
- **17.** For the reaction,  $H_2 + I_2 \square \square$  2HI, the equilibrium constant, K is dimensionalless.
- **18.** The reaction  $2SO_2(g) + O_2(g) = \Box \Box \Box = 2SO_3(g)$ ,  $\Delta H = -X kJ$ , is favoured by high pressure and high temperature.
- **19**. A very high value of K indicates that at equilibrium most of the reactants are converted into products.
- **20.** The value of K for the reaction,  $N_2 + 3H_2 \oplus \oplus \oplus 2NH_3$ , can be increased by applying high pressure or by using a catalyst.

## FILL IN THE BLANKS

- 1. K for the reaction  $2 \text{ A} + \text{B} \oplus \oplus$  2C is  $1.5 \text{ Y} 10^{12}$ . This indicates that at equilibrium the concentration of ...... would be maximum.
- **2.** The reaction  $N_2 + O_2 = 0$  and  $N_2 + O_2 = 0$  and  $N_2 + O_2 = 0$ . The reaction  $N_2 + O_2 = 0$  and  $N_2 + O_2 = 0$ .
- **3**. K for the reaction  $X_2 + Y_2 \square \square \square$  2XY is 100 K for this reaction  $XY \square \square \square \square X_2 + \frac{1}{2}Y_2$  would be .....
- 4. Compared to K for the dissociation,  $2H_2S \blacksquare \square \square = 2H^+ + 2HS^-$ , then K' for the  $H^+ + HS^- \blacksquare \square \square = H_2S$  would have .....
- **5**. The equilibrium constant for a reaction decreases with increase in temperature, the reaction must be ......
- 6. For the reaction,  $PCl_5$  (g)  $H = PCl_3$  (g) +  $Cl_2$  (g),  $K_p$  and  $K_c$  are related as .....
- 7. For the reaction,  $N_2O_4$  (g)  $\exists \Box \Box = 2NO_2$  (g), at equilibrium, increase in pressure shifts the equilibrium in ...... direction.

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INTE 12

- **8**.  $\Delta G^{\circ}$  is related to K by the relation .....
- 9. Vant Hoff's equation is .....
- **0.** When the reaction is at equilibrium, the value of  $\Delta G$  is ......
- 11. Dimensions of equilibrium constant,  $K_c$  for the reaction  $2NH_3 \square \square \square \square N_2 + 3H_2$ , are .....
- 12. The value of K for a reaction can be changed by changing ......
- 13. The law of mass action was proposed by .....
- **14.** The degree of dissociation of  $PCl_5[PCl_5(g) ] \oplus \bigoplus PCl_3(g) + Cl_2(g)]$ , ..... with increase in pressure at equilibrium.
- 15. If concentration quotient, Q is greater than  $K_c$ , the net reaction in taking place in ...... direction.
- **16.** The reaction,  $N_2 + 3H_2 \square \square \square$  2NH<sub>3</sub> would be favoured by ..... pressure.
- 17.  $K_p$  is related to  $K_c$  as ........
- 18. Solubility of a gas in water ..... with increase in temperature.
- **19.** Introduction of inert gas at constant volume to a gaseous reaction at equilibrium results in formation of ...... product.
- 20. The product is more stable than reactants in reaction having ...... K.

## MATCH THE COLUMN

	Column-I (Reactions)		Column-II (Favourable conditions)
(A)	Oxidation of nitrogen	(p)	Addition of inert gas at constant pressure
	$N_2(g) + O_2(g) + 180.5 \text{ kJ} = 1000 \text{ g}$		
(B)	Dissociation of $N_2O_4(g)$	(q)	Decrease in pressure
	$N_2O_4(g)$ + 57.2 kJ = $10^{-10}$ 2NO <sub>2</sub> (g)		
(C)	Oxidation of $NH_3(g)$	(r)	Decrease in temperature
	$4NH_3(g) + 5O_2(g)$ $\square \square \square \square = 4NO(g) + 6H_2O(g)$		
	+ 905.6 kJ		
(D)	Formation of $NO_2(g)$	(s)	Increase in temperature
	$NO(g) + O_3(g) \square \square \square NO_2(g) + O_2(g)$		
	+ 200 kJ		

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	Column-I (Reaction)		Column-II (If α is negligiable w.r.t. 1)	
(A)	2X(g) [] [] [] [] [] Y(g) + Z(g)	(p)	$\alpha = 2 \ \text{Y} \ \sqrt{\text{K}_{c}}$	
(B)	X(g) 目 ⊞	(q)	$\alpha = 3 \ \text{Y} \ \sqrt{\text{K}_{c}}$	
(C)	3X(g) 🗄 🗄 🖽 Y(g) + Z(g)	(r)	$\alpha = (2K_c)^{1/3}$	
(D)	2X(g) 🗄 🗄 🏧 Y(g) + 2Z(g)	(s)	$\alpha = \sqrt{K_c}$	

## ASSERTION & REASON

These questions contains, Statement I (assertion) and Statement II (reason).

- (A) Statement-I is true, Statement-II is true ; Statement-II is correct explanation for Statement-I.
- (B) Statement-I is true, Statement-II is true ; Statement-II is NOT a correct explanation for statement-I
- (C) Statement-I is true, Statement-II is false
- (D) Statement-I is false, Statement-II is true

## 1. Statement-I : The melting point of ice decreases with increase of pressure.

Because

Statement-II : Ice contracts on melting.

2. Statement-I : The equilibrium of A(g)  $\square \square \square$  B(g) + C(g) is not affected by changing the volume. Because

Statement-II : K<sub>c</sub> for the reaction does not depend on volume of the container.

3. Statement-I: For the reaction A(g)  $\exists \Box \Box \Box$  B(g) + C(g), K<sub>p</sub> = 1 atm. If we start with equal moles of all gases at 9 atm of initial pressure, then at equilibrium partial pressure of A increases. Because

**Statement-II** : Reaction quotient  $Q_p > K_p$  hence equilibrium shifts in backward direction.

**4. Statement-I** : For a reaction at equilibrium, the Gibb's free energy of reaction is minimum at constant temp. and pressure.

### Because

 $\label{eq:statement-II} \textbf{Statement-II}: The Gibb's free energy of both reactants and products increases and become equal at equilibrium.$ 

5. **Statement-I** : Equilibrium constant for the reverse reaction is the inverse of the equilibrium constant for the reaction in the forward direction.

### Because

Statement-II : Equilibrium constant depends upon the way in which the reaction is written.

6. Statement-I: For the reaction  $H_2(g) + I_2(g) \oplus \oplus \oplus 2HI(g)$  if the volume of vessel is reduced to half of its original volume, equilibrium concentration of all gases will be doubled.

### Because

**Statement-II** : According to Le Chatelier's principle, reaction shifts in a direction that tends to minimized the effect of the stress.

7. Statement-I : For the reaction at certain temperature

A(g) + B(g)

there will be no effect by addition of inert gas at constant volume.

## Because

Statement-II : Molar concentration of all gases remains constant.

- Statement-I : The catalyst does not alter the equilibrium constant.
  - Because

8.

**Statement-II** : For the catalysed reaction and uncatalysed reaction  $\Delta H$  remains same and equilibrium constant depends on  $\Delta H$ .

## COMPREHENSION BASED QUESTIONS

### Comprehension # 1

On July, 1, 2000, the combined tunnel and bridge connecting Denmark and Sweden was officially opened. It consists of a tunnel from Copenhagen to an artificial Island and a bridge from the island to Malmo in Sweden. The major construction materials employed are concrete and steel. This problem deals with chemical reactions relating to production and degradation of such materials.

Concrete is produced from a mixture of cement, water, sand and small stones. Cement consists primarly of calcium silicates and calcium aluminates formed by heating and grinding of clay and limestone. In the later steps of cement production may lead to formation of unwanted hemihydrate,  $CaSO_4 \cdot \frac{1}{2}H_2O$ . Consider the following reaction :

$$CaSO_4 : 2H_2O(s) \longrightarrow CaSO_4 : \frac{1}{2}H_2O(s) + 1\frac{1}{2}H_2O(g)$$

The following thermodynamic data apply at  $25^{\circ}$ C, standard pressure : 1.00 bar :

Compound	$H^{\circ}/(kJ \text{ mol}^{-1}) (\Delta H_{f}^{\circ})$	$S^{\circ}/(JK^{-1} \text{ mol}^{-1})$
$CaSO_4 \cdot 2H_2O(s)$	-2021.0	194.0
$CaSO_4 \cdot \frac{1}{2}H_2O(s)$	-1575.0	130.5
H <sub>2</sub> O(g)	-241.8	188.6

Gas constant ; R = 8.314 J mol<sup>-1</sup>  $K^{-1}$ 

1.  $\Delta H^{\circ}$  for the transformation of 1.00 kg of  $CaSO_4.2H_2O(s)$  to  $CaSO_4.\frac{1}{2}H_2O(s)$  is : (A) +446 kJ (B) +484 kJ (C) -446 kJ (D) -484 kJ

2. Equilibrium pressure (in bar) of water vapour in a closed vessel containing  $CaSO_4$ .  $2H_2O(s)$ ,

$$CaSO_4(s)$$
 .  $\frac{1}{2}\,H_2O(s)$  and  $H_2O$  (g) at 25°C is :

(A)  $7.35 \text{ H } 10^{-4}$  bar (B)  $2.15 \text{ H } 10^{-4}$  bar (C)  $8.10 \text{ H } 10^{-3}$  bar (D)  $7.00 \text{ H } 10^{-4}$  bar

**3.**Temperature at which the equilibrium water vapour pressure is 1.00 bar.(A) 107°C(B) 380°C(C) 215°C(D) 240°C

#### Comprehension # 2

### Questions are based on the manufacture of Na<sub>2</sub>CO<sub>3</sub> by Solvay process :

In the manufacture of Na2CO3(s) by Solvay process, NaHCO3(s) is decomposed by heating :

$$2NaHCO_3(s) = \square \square Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

$$K_{p} = 0.23$$
 at 100°C  $\Delta H^{\circ} = 136$  kJ

1. If a sample of  $NaHCO_3$  (s) is brought to a temperature of 100°C in a closed container total gas pressure at equilibrium is :

(A) 0.96 atm	(B)	0.23	atm
(C) 0.48 atm	(D)	0.46	atm

- A mixture of 1.00 mol each of NaHCO<sub>3</sub>(s) and Na<sub>2</sub>CO<sub>3</sub>(s) is introduced into a 2.5 L flask in which P<sub>CO2</sub> = 2.10 atm and P<sub>H2O</sub> = 0.94 atm. When equilibrium is established at 100°C, then partial pressure of :
   (A) CO<sub>2</sub>(r) and U<sub>2</sub>(r) will be an extend to relate their initial pressure.
  - (A)  $\mathrm{CO}_2(g)$  and  $\mathrm{H}_2\mathrm{O}(g)$  will be greater than their initial pressure
  - (B)  $\mathrm{CO}_2(g)$  and  $\mathrm{H}_2\mathrm{O}(g)$  will be less than their initial pressure
  - (C)  $CO_2(g)$  will be larger and that of  $H_2O(g)$  will be less than their initial pressure
  - (D)  $H_2O(g)$  will be larger and that of  $CO_2(g)$  will be less than their initial pressure

MIS	CELLANEOUS TYPE Q	UESTION ANS	SWER KEY	EXERCISE -3
•	<u>True / False</u>			
	<b>1</b> . T	<b>2.</b> T	<b>3.</b> F	<b>4.</b> F
	<b>5.</b> T	<b>6</b> . F	<b>7.</b> T	<b>8.</b> T
	<b>9.</b> F	<b>10.</b> T	<b>11.</b> T	<b>12</b> . T
	<b>13</b> . F	<b>14.</b> F	<b>15.</b> F	<b>16</b> . F
	<b>17</b> . T	<b>18.</b> F	<b>19.</b> T	<b>20.</b> F
•	<u>Fill in the Blanks</u>	2		
	<b>1.</b> C	<b>2.</b> high	<b>3.</b> $\frac{1}{10}$	<b>4.</b> $\frac{1}{\sqrt{K}}$
	5. exothermic	<b>6.</b> $K_{\rm P} = K_{\rm C} ({\rm RT})$	7. backward	<b>8.</b> $\Delta G^{\circ} = -RT \ln K$
	$9.  \log \frac{K_2}{K_1} = \frac{\Delta H^\circ}{2.303F}$	$\left[\frac{T_2 - T_1}{T_2 T_1}\right]$	10. zero	<b>11.</b> mol <sup>2</sup> L <sup>-2</sup>
	12. temperature	13. Guldberg and Waage	14. decreases	15. backward
	<b>16.</b> high <b>20.</b> large value of	<b>17.</b> $K_{p} = K_{C} (RT)^{\Delta n}$	18. decreases	<b>19.</b> same amount of
•	Match the Colum	<u>n</u>		
	<b>1.</b> A - (s), B - (p,q,s), C	- (p,q,r), D - (r)	<b>2.</b> A - (p), B - (s), C - (q), D -	(r)
•	<u>Assertion - Reaso</u>	on Questions		
	<b>1</b> . A	<b>2.</b> D	<b>3.</b> A	<b>4.</b> C
	<b>5.</b> A	<b>6.</b> B	<b>7.</b> A	<b>8.</b> A
•	Comprehension	Based Questions		
	Comprehension #1	: <b>1</b> . B <b>2</b> . C	<b>3.</b> A	
	Comprehension #2	: <b>1</b> . A <b>2</b> . B		

## EXERCISE-04 [A]

## CONCEPTUAL SUBJECTIVE EXERCISE

#### Reaction quotient and equillibrium constant

- 1. The initial concentration or pressure of reactants and products are given for each of the following systems. Calculate the reaction quotient and determine the directions in which each system will shift to reach equilibrium.
  - (a)  $2NH_3$  (g)  $\exists \Box \Box D$   $N_2$  (g)  $+ 3H_2$  (g) K = 17  $[NH_3] = 0.20 \text{ M}$ ;  $[N_2] = 1.00 \text{ M}$ ;  $[H_2] = 1.00 \text{ M}$ (b)  $2NH_3$  (g)  $\exists \Box \Box D$   $N_2$  (g)  $+ 3H_2$  (g)  $K_p = 6.8 \text{ Y} 10^4 \text{ atm}^2$ Initial pressure :  $NH_3 = 3.0 \text{ atm}$ ;  $N_2 = 2.0 \text{ atm}$ ;  $H_2 = 1.0 \text{ atm}$
  - (c)  $2SO_3(g) = 0.00 \text{ M}$ ;  $[SO_2] = 1.00 \text{ M}$ ;  $[O_2] = 1.00 \text{ M}$
  - (d)  $2SO_3(g) = 0$  (g)  $2SO_2(g) + O_2(g) = 16.5$  atm Initial pressure :  $SO_3 = 1.0$  atm ;  $SO_2 = 1.0$  atm ;  $O_2 = 1.0$  atm
  - (e) 2NO (g) +  $Cl_2$  (g)  $\square \square \square$  2NOCl (g) K = 4.6  $\lor 10^4$ [NO] = 1.00 M ; [Cl\_2] = 1.00 M ; [NOCl] = 0 M
- 2. Among the solubility rules, the statement that all chlorides are soluble except  $Hg_2Cl_2$ , AgCl, PbCl<sub>2</sub>, and CuCl.
  - (a) Write the expression for the equilibrium constant for the reaction represented by the equation

AgCl (s)  $\square$   $\square$   $\square$   $\square$   $\square$   $\square$   $\square$   $\square$   $\square$  (aq)  $\square$   $\square$  (aq)

Is K greater than 1, less than 1, or about equal to 1? Explain your answer.

(b) Write the expression for the equilibrium constant for the reaction represented by the equation  $Pb^{2+}(aq) + 2Cl^{-}(aq) \square \square \square PbCl_{2}$  (s)

Is K greater than 1, less than 1, or about equal to 1? Explain your answer.

**3.** Benzene is one of the compounds used as octane enhancers in unleaded gasoline. It is manufactured by the catalytic conversion of acetylene to benzene.

 $3C_2H_2 \longrightarrow C_6H_6$ 

Would this reaction be most useful commercially if K were about 0.01, about 1, or about 10? Explain your answer.

**4.** For which of the following reactions will the equilibrium mixture contain an appreciable concentration of both reactants and products?

(a)	$\operatorname{Cl}_2(g)$ $\exists$ $\exists$ $\exists$ $\exists$ $\exists$ $d$ $\exists$ $d$	$K_{c} = 6.4 \text{ H} 10^{-39}$
(b)	$\operatorname{Cl}_2(g)$ + 2NO (g) $\exists \exists \exists \exists d d d d d d d d d d d d d d d $	$K_{c} = 3.7 \text{ H} 10^{8}$
(c)	$\operatorname{Cl}_2(g)$ + 2NO <sub>2</sub> (g) $\square$ $\square$ 2NO <sub>2</sub> Cl (g) ;	$K_{c} = 1.8$

5. The value of  $K_c$  for the reaction 3  $O_2$  (g)  $\square \square \square$  2 $O_3$  (g) is 1.7  $\lor 10^{-56}$  at 25°C. Do you expect pure air at 25°C to contain much  $O_3$  (ozone) when  $O_2$  and  $O_3$  are in equilibrium ? If the equilibrium concentration of  $O_2$  in air at 25°C is 8  $\lor 10^{-3}$  M, what is the equilibrium concentration of  $O_3$ .

- 6. At 1400 K,  $K_c = 2.5 \text{ H} 10^{-3}$  for the reaction  $CH_4(g) + 2H_2S \square \oplus CS_2(g) + 4H_2(g)$ . A 10.0 L reaction vessel at 1400 K contains 2.0 mol of  $CH_4$ , 3.0 mol of  $CS_2$ , 3.0 mol of  $H_2$  and 4.0 mol of  $H_2S$ . Is this reaction mixture at equilibrium ? If not, in which direction does the reaction proceed to reach equilibrium ?
- 7. An equilibrium mixture of  $N_2$ ,  $H_2$  and  $NH_3$  at 700 K contains 0.036 M  $N_2$  and 0.15 M  $H_2$ . At this temperature,  $K_c$  for the reaction  $N_2(g) + 3H_2(g) \oplus 2NH_3$  (g) is 0.29. What is the concentration of  $NH_3$ ?
- 8. The air pollutant NO is produced in automobile engines from the high temperature reaction  $N_2$  (g) +  $O_2$  (g)  $\square \square \square$  2NO (g) ;  $K_c = 1.7 \ \text{M} \ 10^{-3}$  at 2300 K. If the initial concentrations of  $N_2$  and  $O_2$  at 2300 K are both 1.40 M, what are the concentration of NO,  $N_2$  and  $O_2$  when the reaction mixture reaches equilibrium?
- 9. At a certain temperature, the reaction  $PCl_5$  (g)  $\square \square \square$   $PCl_3$  (g) +  $Cl_2$  (g) has an equilibrium constant  $K_c = 5.8 \text{ H } 10^{-2}$ . Calculate the equilibrium concentrations of  $PCl_5$ ,  $PCl_3$  and  $Cl_2$  if only  $PCl_5$  is present initially, at a concentration of 0.160 M.
- **10.** At 700 K,  $K_p = 0.140$  for the reaction  $ClF_3(g) \square \square \square$  ClF (g) +  $F_2(g)$ . Calculate the equilibrium partial pressure of  $ClF_3$ , ClF and  $F_2$  if only  $ClF_3$  is present initially ; at a partial pressure of 1.47 atm.

## Homogeneous equilibria degree of dissociation, vapour density and equilibrium constant

- 12. At 46°C,  $K_p$  for the reaction  $N_2O_4$  (g)  $\square \square \square \square$  2NO<sub>2</sub> (g) is 0.667 atm. Compute the percent dissociation of  $N_2O_4$  at 46°C at a total pressure of 380 Torr.
- 13. When 36.8 g  $N_2O_4$  (g) is introduced into a 1.0 litre flask at 27°C. The following equilibrium reaction occurs :

 $N_2O_4$  (g)  $10^{-10}$   $2NO_2$  (g) ;  $K_n = 0.1642$  atm.

- (a) Calculate  $K_c$  of the equilibrium reaction.
- (b) What are the number of moles of  $N_2O_4$  and  $NO_2$  at equilibrium?
- (c) What is the total gas pressure in the flask at equilibrium?
- (d) What is the percent dissociation of  $N_2O_4$ ?
- 14. At some temperature and under a pressure of 4 atm,  $PCl_5$  is 10% dissociated. Calculate the pressure at which  $PCl_5$  will be 20% dissociated, temperature remaining same.
- 15. In a mixture of  $N_2$  and  $H_2$  in the ratio of 1:3 at 64 atmospheric pressure and 300°C, the percentage of ammonia under equilibrium is 33.33 by volume. Calculate the equilibrium constant of the reaction using the equation.

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

- **16.** The system  $N_2O_4 \oplus \oplus \oplus 2 NO_2$  maintained in a closed vessel at 60°C & pressure of 5 atm has an average (i.e. observed) molecular weight of 69, calculate  $K_p$ . At what pressure at the same temperature would the observed molecular weight be (230/3)?
- **17.** The vapour density of  $N_2O_4$  at a certain temperature is 30. Calculate the percentage dissociation of  $N_2O_4$  at this temperature.  $N_2O_4$  (g)  $\exists \Box \Box \Box = 2NO_2$  (g).
- **18.** In the esterification  $C_2H_5OH(\ell) + CH_3COOH(\ell) \oplus CH_3COOC_2H_5(\ell) + H_2O(\ell)$  an equimolar mixture of alcohol and acid taken initially yields under equilibrium, the water with mole fraction = 0.333. Calculate the equilibrium constant.

#### Hetrogeneous equilibrium

- **19.** Solid Ammonium carbamate dissociates as :  $NH_2COONH_4$  (s)  $\square \square \square$   $2NH_3$  (g) +  $CO_2$  (g). In a closed vessel solid ammonium carbamate is in equilibrium with its dissociation products. At equilibrium, ammonia is added such that the partial pressure of  $NH_3$  at new equilibrium now equals the original total pressure. Calculate the ratio of total pressure at new equilibrium to that of original total pressure.
- **20.** A sample of  $CaCO_3$  (s) is introduced into a sealed container of volume 0.821 litre & heated to 1000 K until equilibrium is reached. The equilibrium constant for the reaction  $CaCO_3$  (s)  $\square \square \square$  CaO (s) + CO<sub>2</sub> (g) is 4  $\le 10^{-2}$  atm at this temperature. Calculate the mass of CaO present at equilibrium.
- **21.** Anhydrous calcium chloride is often used as a dessicant. In the presence of excess of  $CaCl_2$ , the amount of the water taken up is governed by  $K_p = 6.4 \text{ H} 10^{85}$  for the following reaction at room temperature,  $CaCl_2(s) + 6H_2O(g) \square \square \square$   $CaCl_2$ .  $6H_2O(s)$ . What is the equilibrium vapour pressure of water in a closed vessel that contains  $CaCl_2(s)$ ?
- **22.** 20.0 grams of  $CaCO_3$  (s) were placed in a closed vessel, heated & maintained at 727°C under equilibrium  $CaCO_3$  (s)  $\square$   $\square$   $\square$   $\square$  CaO (s) +  $CO_2$  (g) and it is found that 75% of  $CaCO_3$  was decomposed. What is the value of K<sub>n</sub>? The volume of the container was 15 litres.

### Changes in concentration at equilibrium Le Chatelier's principle

23. Suggest four ways in which the concentration of hydrazine,  $N_2H_4$ , could be increased in an equilibrium described by the equation

 $N_2(g) + 2H_2(g) \square \square \square N_2H_4(g)$   $\Delta H = 95 \text{ kJ}$ 

24. How will an increase in temperature and increase in pressure affect each of the following equilibria?

(a)	$2NH_3$ (g) $\blacksquare \blacksquare \blacksquare = N_2$ (g) + $3H_2$ (g)	$\Delta H = 92 \text{ kJ}$
(b)	$N_2$ (g) + $O_2$ (g) $\square$ $\square$ 2NO (g)	$\Delta H = 181 \text{ kJ}$
(c)	$2O_3$ (g) $\square$ $\square$ $3$ $O_2$ (g)	$\Delta H = -285 \text{ kJ}$
(d)	$CaO(s) + CO_2(g) \square \square \square CaCO_3(s)$	$\Delta H = -176 \text{ kJ}$

(a) Water gas, a mixture of H<sub>2</sub> and CO, is an important industrial fuel produced by the reaction of steam with red-hot coke, essentially pure carbon. Write the expression for the equilibrium constant for the reversible reaction.

C (s) + H<sub>2</sub>O (g)  $\Box$   $\Box$  CO (g) + H<sub>2</sub> (g)  $\Delta$ H = 131.30 kJ

- (b) Assume that equilibrium has been established and predict how the concentration of each reactant and product will differ at a new equilibrium if (1) more C is added. (2)  $H_2O$  is removed. (3) CO is added (4) the pressure on the system is increased. (5) the temperature of the system is increased.
- 26. Ammonia is weak base that reacts with water according to the equation

 $NH_3$  (aq) +  $H_2O(l)$   $H_2H_4^+$  (aq) +  $OH^-$  (aq)

Will any of the following increase the percent of ammonia that is converted to the ammonium ion in water?

- (a) Addition of NaOH.
- (b) Addition of HCl.
- (c) Addition of NH<sub>4</sub>Cl.
- **27.** Suggest two ways in which equilibrium concentration of  $Ag^+$  can be reduced in a solution of  $Na^+$ ,  $Cl^-$ ,  $Ag^+$  and  $NO_3^-$ , in contact with solid AgCl.

### Kinetics and equilibrium constant

- **28.** Consider a general single-step reaction of the type  $A + B \square \square$  C. Show that the equilibrium constant is equal to the ratio of the rate constant for the forward and reverse reaction,  $K_c = K_f/K_r$ .
- 29. Consider the reaction of chloromethane with OH<sup>-</sup> in aqueous solution

 $CH_3Cl$  (aq) +  $OH^-$  (aq)  $\exists \Box_{k_r}^{k_1} \Box CH_3OH$  (aq) +  $Cl^-$  (aq)

At 25°C, the rate constant for the forward reaction is 6  ${\rm Y} \, 10^{-6} \, {\rm M}^{-1} \, {\rm s}^{-1}$ , and the equilibrium constant  ${\rm K}_{\rm c}$  is 1  ${\rm Y} \, 10^{16}$ . Calculate the rate constant for the reverse reaction at 25°C.

**30**. The progress of the reaction

A  $\square$   $\square$   $\square$  mB with time, is presented in figure, Determine

- (i) the value of n.
- (ii) the equilibrium constant K.
- (iii) the initial rate of conversion of A.



#### Temperature dependence of equilibrium constant

31. Listed in the table are forward and reverse rate constants for the reaction 2NO (g)  $\square$   $\square$   $\square$   $N_2$  (g) +  $O_2$  (g)

Temperature (K)	$k_{f} (M^{-1}s^{-1})$	$k_r (M^{-1}s^{-1})$
1400	0.29	1.1 Ч 10 <sup>-6</sup>
1500	1.3	1.4 Ч 10 <sup>-5</sup>

Is the reaction endothermic or exothermic?

**32.** Rate of disappearance of the reactant A at two different temperature is given by A  $\square \square \square$  B

$$\frac{-d[A]}{dt} = (2 \text{ Y } 10^{-2} \text{ S}^{-1}) \text{ [A]} -4 \text{ Y } 10^{-3} \text{ S}^{-1} \text{ [B]} \text{ ; } 300 \text{ K}$$

$$\frac{-d[A]}{dt} = (4 \text{ U} 10^{-2} \text{ S}^{-1}) \text{ [A]} -16 \text{ U} 10^{-4} \text{ S}^{-1} \text{ [B]} \text{ ; } 400 \text{ K}$$

Calculate heat of reaction in the given temperature range. When equilibrium is set up.

**33.** The  $K_p$  for reaction A + B  $\square \square$  C + D is 1.34 at 60°C and 6.64 at 100°C. Determine the free energy change of this reaction at each temperature and  $\Delta H^\circ$  for the reaction over this range of temperature?

#### Equilibrium expressions and equilibrium constants

- **34.** If  $K_c = 7.5 \ \text{H} \ 10^{-9}$  at 1000 K for the reaction  $N_2(g) + O_2(g) = 2NO(g)$ , what is  $K_c$  at 1000 K for the reaction 2NO (g) = 0 and 0 and 0 and 0 are the reaction 2NO (g) = 0 and 0 are the reaction 0 at 0 and 0 are the reaction 0 are the reaction 0 and 0 are the reaction 0 and 0 are the reaction 0 and 0 are the reaction 0 are the reaction 0 and 0 are the reaction 0 and 0 are the reaction 0 are the reaction 0 are the reaction 0 and 0 are the reaction 0 areaction 0 areaction 0 are the reaction 0 areaction 0 a
- **35.** A sample of HI (9.30  $\Upsilon$  10<sup>-3</sup> mol) was placed in an empty 2.00 L container at 1000 K. After equilibrium was reached, the concentration of I<sub>2</sub> was 6.29  $\Upsilon$  10<sup>-4</sup> M. Calculate the value of K<sub>c</sub> at 1000 K for the reaction H<sub>2</sub> (g) + I<sub>2</sub> (g)  $\exists \Box \Box$  2HI (g).
- **36.** The vapour pressure of water at 25°C is 0.0313 atm. Calculate the values of  $K_p$  and  $K_c$  at 25°C for the equilibrium  $H_2O(\ell) \square \square \square H_2O(g)$ .

- **37.** For each of the following equilibria, write the equilibrium constant expression for  $K_c$ . Where appropriate, also write the equilibrium constant expression for  $K_p$ .
  - (a)  $\operatorname{Fe}_2O_3$  (s) + 3CO (g)  $\square \square \square$  2Fe ( $\ell$ ) + 3 CO<sub>2</sub> (g)
  - (b)  $4Fe(s) + 3 O_2(g) = 2Fe_2O_3(s)$
  - (c)  $BaSO_4$  (s) BaO (s) +  $SO_3$  (g)
  - (d)  $BaSO_4$  (s)  $\Box \Box \Box \Box$   $Ba^{2+}$  (aq) +  $SO_4^{2-}$  (aq)

#### General problems

**38.** When 0.5 mol of  $N_2O_4$  is placed in a 4.00 L reaction vessel and heated at 400 K, 79.3 % of the  $N_2O_4$  decomposes to  $NO_2$ .

Calculate K<sub>c</sub> and K<sub>p</sub> at 400 K for the reaction  $N_2O_4$  (g) 100 M 2 NO<sub>2</sub> (g).

- **39.** At 100 K, then value of  $K_c$  for the reaction  $C(s) + H_2O(g) \oplus \oplus O(g) + H_2(g)$  is 3.0  $H_2O^2$ . Calculate equilibrium concentrations of  $H_2O$ ,  $CO_2$  and  $H_2$  in the reaction mixture obtained by heating 6.0 mole of steam and an excess of solid carbon in a 5.0 L container. What is the molar composition of the equilibrium mixture?
- **40.** When 1.0 mol of PCl<sub>5</sub> is introduced into a 5.0 L container at 500 K, 78.5 % of the PCl<sub>5</sub> dissociates to given an equilibrium mixture of PCl<sub>5</sub>, PCl<sub>3</sub> and Cl<sub>2</sub>.

 $PCl_{5}(g) \square \square \square PCl_{3}(g) + Cl_{2}(g)$ 

- (a) Calculate the values of  $K_c$  and  $K_p$ .
- (b) If the initial concentrations in a particular mixture of reactants and products are  $[PCl_5] = 0.5 \text{ M}$ ,  $[PCl_3] = 0.15 \text{ M}$ , and  $[Cl_2] = 0.6 \text{ M}$ , in which direction does the reaction proceed to reach equilibrium?

What are the concentrations when the mixture reaches equilibrium?

#### Thermodynamic and equilibrium constant

41.  $\alpha$ -D-Glucose undergoes mutarotation to  $\beta$ -D-Glucose in aqueous solution. If at 298 K there is 60% conversion. Calculate  $\Delta G^{\circ}$  of the reaction.

 $\alpha$ -D-Glucose  $\beta$ -D-Glucose

42. For the reaction at 298 K

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

 $\Delta H^{\circ} = -$  29.8 kcal ;  $\Delta S^{\circ} = -$  0.1 kcal/K

Calculate  $\Delta G^{\circ}$  and K.

**43.** The equilibrium constant of the reaction  $2 C_3 H_6$  (g)  $\square \square \square \square C_2 H_4$  (g) +  $C_4 H_8$  (g) is found to fit the expression

$$\ell n K = -1.04 - \frac{1088}{T}$$

Calculate the standard reaction enthalpy and entropy at 400 K.

- **44.**  $PCl_5$  dissociates according to the reaction  $PCl_5$  (g)  $\square \square \square \square \square \square$   $PCl_3$  (g) +  $Cl_2$  (g). At 523 K,  $K_p = 1.78$  atm. Find the density of the equilibrium mixture at a total pressure of 1 atm.
- **45**. The following data for the equilibrium composition of the reaction

2 Na (g)

- at 1.013 MP<sub>a</sub> pressure and 1482.53 K have been obtained.
  - mass % Na (monomer gas) = 71.3

mass %  $Na_2$  (dimer gas) = 28.7

Calculate the equilibrium constant  $K_{_{D}}$ .

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**46.** A certain gas A polymerizes to a small extent at a given temperature & pressure, nA  $\square$   $\square$   $\square$   $\square$   $A_n$ . Show

that the gas obeys the approx equation  $\frac{PV}{RT} = \left[1 - \frac{(n-1)K_c}{V^{n-1}}\right]$  where  $K_c = \frac{\left[A_n\right]}{\left[A\right]^n}$  & V is the volume of the container. Assume that initially one mole of A was taken in the container.

**47.** When 1 mole of A (g) is introduced in a closed rigid 1 litre vessel maintained at constant temperature the following equilibria are established.

The pressure at equilibrium is twice the initial pressure. Calculate the value of  $\frac{K_{C_2}}{K_{C_1}}$  if  $\frac{[C]_{eq}}{[B]_{eq}} = \frac{1}{5}$ 

СС	DNCEPTUAL SUBJ	ECTIVE EXERCISE	ANSWER KEY		EXERCISE-4(A)
1.	(a) 25, shifts left,	(b) 0.22, shifts right,	(c) $\infty$ , shifts left,	(d) 1, shifts right,	(e) 0, shifts right
2.	(a) $K = [Ag^+] [Cl^-]$	is less than 1. AgCl is insol	uble thus the concen	tration of ions are muc	ch less than 1 M
	(b) $K = 1/[Pb^{2+}]$ [ concentration of	Cl <sup>-</sup> ] <sup>2</sup> is greater than one be of ions to a low level.	cause PbCl <sub>2</sub> is insolu	uble and formation of t	the solid will reduce the
3.	K about 10		<b>4.</b> c	<b>5.</b>	~ 9 Y 10 <sup>-32</sup> mol/L
6. <sup>-</sup>	The reaction is not	in equilibrium because $Q_{c}$ >	$\rm K_{_c}$ . The reaction will	proceed from right to	left to reach equilibrium.
7.	5.9 Ч 10 <sup>-3</sup> М		<b>8.</b> [NO] = 0.056 M	I, $[N_2] = [O_2] = 1.37$ M	1
9.	$[PCl_3] = [Cl_2] = 0.0$	071 M, $[PCl_5] = 0.089$ M	<b>10.</b> $P_{CF} = P_{F_2} = 0.38$	89 atm, $P_{CIF_3} = 1.08$ atm	n
11.	$K_{\rm p} = 0.4, \ \alpha \simeq 0.1$		<b>12.</b> 50%		
13.	(a) 6.667 Ч 10 <sup>-3</sup> r	mol $L^{-1}$ ; (b) n ( $N_2O_4$ ) = 0.37	$^{\prime}4 \text{ mol} ; n (NO_2) = 0.$	.052 mol ; (c) 10.49 a	tm (d) 6.44%
14.	0.97 atm		<b>15.</b> $K_p = 1.3 \text{ H} 10^{-3}$	<sup>3</sup> atm <sup>-2</sup>	
16.	$K_p = 2.5 \text{ atm}$ , P	= 15 atm	<b>17.</b> 53.33%	<b>18.</b> K = 4	<b>19</b> . 31/27
20.	22.4 mg		<b>21.</b> $P_{H_{2}O} = 5 \text{ H } 10^{-1}$	<sup>15</sup> atm	<b>22.</b> 0.821 atm
23.	add $N_2$ , add $H_2$ , i	increase the pressure, heat	the reaction		
24.	(a) shift right, shif	t left, (b) shift right, no effe	ct, (c) shift left, shift l	left, (d) shift left, shift r	ight
25.	(a) K = [CO][H <sub>2</sub> ]/	/ [H <sub>2</sub> O] ;			
	(b) in each of the change.	following cases the mass o	f carbon will change,	, but its concentration	(activity) will not
1.	[H <sub>2</sub> O] no change,	[CO] no change, $[H_2]$ no c	hange; 2. $[H_2 C]$	D] decrease, [CO] decre	ease, [H <sub>2</sub> ] decrease ;
3.	[H <sub>2</sub> O] increase, [O	CO] increase, [H <sub>2</sub> ] decrease	; 4. [H <sub>2</sub> C	)] increase, [CO] decre	ase, [H <sub>2</sub> ] decrease ;
5.	[H <sub>2</sub> O] decrease, [0	CO] increase, $[H_2]$ increase	;		
26.	.b	<b>27.</b> Add NaCl or some	other salt that produc	ces Cl <sup>-</sup> in the solution.	Cool the solution
28.	$k_{f}[A][B] = k_{r}[C];$	; $\frac{k_f}{k_r} = \frac{[C]}{[A][B]} = k_c$	<b>29.</b> 6 Ч 10 <sup>-22</sup>	<b>30.</b> (i) 2 ; (ii) 1.2 mol,	/L ; (iii) 0.1 moles/hr
31.	The reaction is e	xothermic	<b>32.</b> 16.06 kJ		
33.	-810 J/mol ; -58	872 J/mol and 41.3 kJ/m	ol		<b>34.</b> 1.3 Ч 10 <sup>8</sup>
35.	29.0		<b>36.</b> $K_{p} = 0.0313$ at	m, $K_c = 1.28 \text{ H} 10^{-3}$	
37.	(a) $K_c = \frac{[CO_2]^3}{[CO]^3}$ , I	$K_{p} = \frac{(P_{CO_{2}})^{3}}{(P_{CO})^{3}}$ , (b) $K_{c} = \frac{1}{[O_{2}]^{3}}$	$\frac{1}{3}$ , $K_p = \frac{1}{(P_{O_2})^3}$ ; (c)	$K_{c} = [SO_{3}], K_{p} = P_{SO_{3}}$	(d) $K_c = [Ba^{2+}] [SO_4^{2-}]$
38.	$K_{c} = 1.51, K_{p} = 4$	49.6	<b>39.</b> $[CO] = [H_2] = 0$	$0.18 \text{ M} ; [\text{H}_2\text{O}] = 1.02$	2 M
40.	(a) $K_{c} = 0.573$ and	nd $K_p = 23.5$ ; (b) to the rig	ht, $[PCl_5] = 0.365$ M	$I; [PCl_3] = 0.285 M;$	[Cl <sub>2</sub> ] = 0.735 M
41.	-1.005 kJ/mol		<b>42.</b> $\Delta G^{\circ} = 0$ ; K =	1	
43.	$\Delta H^{\circ} = 9.04 \text{ kJ/m}$	nol ; $\Delta S^\circ = -8.64 \text{ J} / \text{mol}^-$	<sup>1</sup> K <sup>-1</sup>	<b>44.</b> 2.71 g/L	
45.	$P_{Na} = 0.843 \text{ M P}$	Pa, $P_{Na_2} = 0.170$ M Pa, $k_p =$	0.293	<b>46.</b> To be proved	<b>47.</b> 4

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## EXERCISE-04 [B]

**BRAIN STORMING SUBJECTIVE EXERCISE** 

1. 0.15 mole of CO taken in a 2.5 litre flask is maintained at 750 K along with a catalyst so that the following reaction can take place ;

 $CO(g) + 2H_2(g) \square \square \square CH_3OH(g).$ 

Hydrogen is introduced untill the total pressure of the system is 8.5 atm at equilibrium and 0.08 mole of methanol is formed. Calculate :

- (i)  $K_{D} \& K_{c};$
- (ii) the final pressure if the same amount of CO and  $H_2$  as before are used, but with no catalyst so that the reaction does not take place.
- 2. In a vessel, two equilibrium are simultaneously established at the same temperature as follows :

$N_2(g) + 3H_2(g)$	2NH <sub>3</sub> (g)	(i)
$N_2(g) + 2H_2(g)$	$N_2H_4(g)$	(ii)

Initially the vessel contains  $N_2$  and  $H_2$  in the molar ratio of 9 : 13. The equilibrium pressure is  $7P_0$ , in which pressure due to ammonia is  $P_0$  and due to hydrogen is  $2P_0$ . Find the values of equilibrium constant ( $K_p$ 's) for both the reactions.

**3.** The decomposition of solid ammonium carbamete,  $(NH_4)(NH_2CO_2)$ , to gaseous ammonia and carbon dioxide is an endothermic reaction.

 $(NH_4)$   $(NH_2CO_2)$  (s)  $\square \square \square \square \square \square \square$   $2NH_3(g) + CO_2(g)$ 

- (a) When solid (NH<sub>4</sub>) (NH<sub>2</sub>CO<sub>2</sub>) is introduced into an evacuated flask at 25°C, the total pressure of gas at equilibrium is 0.116 atm. What is the value of  $K_p$  at 25°C ?
- (b) Given that the decomposition reaction is at equilibrium, how would the following changes affect the total quantity of  $NH_3$  in the flask once equilibrium is re-established?
- (i) Adding CO<sub>2</sub>
- (ii) Adding  $(NH_4)$   $(NH_2CO_2)$
- (iii) Removing CO<sub>2</sub>
- (iv) Increasing the total volume
- (v) Adding neon
- (vi) Increasing the temperature

**4**. A container contains three gases. A, B and C in equilibrium A  $\square \square \square$  2B + C

At equilibrium the concentration of A was 3 M, and of B was 4 M. On doubling the volume of container, the new equilibrium concentration of B was 3M. Calculate K<sub>c</sub> and initial equilibrium concentration of C.

5. The density of an equilibrium mixture of  $N_2O_4$  and  $NO_2$  at 1 atm and 346 K is 1.8 g/L. Calculate  $K_c$  for the reaction.

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

- 6. At 90°C, the following equilibrium is established :
  - $H_2(g) + S(s) = H_2S(g)$

 $K_{p} = 6.8 \text{ H} 10^{-2}$ 

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If 0.2 mol of hydrogen and 1.0 mol of sulphur are heated to 90°C in a 1.0 litre vessel, what will be the partial pressure of  $H_2S$  at equilibrium ?

- 7. At 817°C,  $K_p$  for the reaction between pure  $CO_2$  and excess hot graphite to form 2CO(g) is 10 atm.
  - (a) What is the analysis of the gases at equilibrium at  $817^{\circ}$ C & a total pressure of 4.0 atm ? What is the partial pressure of CO<sub>2</sub> at equilibrium ?
  - (b) At what total pressure will the gas mixture analyze 6%,  $\mathrm{CO}_{_2}$  by volume ?
- 8. For the reaction  $N_2O_4 \oplus \oplus \oplus 2NO_2$ , equilibrium mixture contains  $NO_2$  at P = 1.1 atm &  $N_2O_4$  at P = 0.28 atm at 350 K. The volume of the container is doubled. Calculate the equilibrium pressures of the two gases when the system reaches new equilibrium.

- 9. The degree of dissociation of HI at a particular temperature is 0.8. Find the volume of 1.5 M sodium thiosulphate solution required to react completely with the iodine present at equilibrium in acidic conditions, when 0.135 mol each of  $H_2$  and  $I_2$  are heated at 440 K in a closed vessel of capacity 2.0 L.
- 10. A mixture of hydrogen & iodine in the mole ratio 1.5:1 is maintained at 450°C. After the attainment of equilibrium  $H_2(g) + I_2(g) \oplus \oplus \oplus 2HI(g)$ , it is found on analysis that the mole ratio of  $I_2$  to HI is 1:18. Calculate the equilibrium constant & the number of moles of each species present under equilibrium, if initially, 127 g of iodine were taken.
- **11.** The equilibrium constant for the reaction  $CO(g) + H_2O(g) \oplus \oplus \oplus CO_2(g) + H_2(g)$  is 7.3 at 450°C & 1 atm pressure. The initially concentration of water gas [CO & H<sub>2</sub> in equimolar ratio] & steam are 2 moles & 5 moles respectively. Find the number of moles of CO, H<sub>2</sub>, CO<sub>2</sub> & H<sub>2</sub>O (vapour) at equilibrium.
- 12. At 1200°C, the following equilibrium is established between chlorine atoms & molecule.

## $Cl_2(g) \square \square \square 2Cl(g)$

The composition of equilibrium mixture may be determined by measuring the rate of effusion of the mixture through a pin hold. It is found that at 1200°C and 1 atm pressure the mixture effuses 1.16 times as fast as krypton effuses under the same condition. Calculate the equilibrium constant  $K_c$ .

**13.** Two solids X and Y dissociate into gaseous products at a certain temperature as follows :

X(s)  $\exists \Box \Box = A(g) + C(g)$ , and Y(s)  $\exists \Box \Box = B(g) + C(g)$ . At a given temperature, pressure over excess solid X is 40 mm and total pressure over solid Y is 60 mm. Calculate :

- (a) the values of  $K_{p}$  for two reactions (in mm)
- (b) the ratio of moles of A and B in the vapour state over a mixture of X and Y.
- (c) the total pressure of gases over a mixture of X and Y.
- **14.**  $SO_3$  decomposes at a temperature of 1000 K and at a total pressure of 1.642 atm. At equilibrium, the density of mixture is found to be 1.28 g/L in a vessel of 90 litres. Find the degree of dissociation of  $SO_3$  for  $SO_3 \square \square \square$   $SO_2 + 1/2O_2$ .
- **15.** The density of an equilibrium mixture of  $N_2O_4$  and  $NO_2$  at 101.32 KP<sub>a</sub> is 3.62 g dm<sup>-3</sup> at 288 K and 1.84 g dm<sup>-3</sup> at 348 K. What is the heat of the reaction for  $N_2O_4 \square \square \square \square \square$  2NO<sub>2</sub>(g).
- **16**. The equilibrium constant for the following reaction at 1395 K.

$2H_2O$	$2H_2 + O_2$	$K_1 = 2.1 \text{ H} 10^{-13}$
2CO <sub>2</sub>	$2CO + O_2$	$K_2 = 1.4 \text{ H} 10^{-12}$

Calculate the value of K for the reaction :  $H_2 + CO_2 \square \square \square CO + H_2O$ 

- **17.** A saturated solution of iodine in water contains 0.33 g  $I_2/L$ . More than this can dissolve in a KI solution because of the equilibrium :  $I_2$  (aq) +  $I^-$  (aq)  $I^{\pm} I^{\pm}_3$  (aq). A 0.10 M KI solution (0.10 MI<sup>-</sup>) actually dissolves 12.5 g of iodine/L, most of which is converted to  $I_3^-$ . Assuming that the concentration of  $I_2$  in all saturated solutions is the same, calculate the equilibrium constant for the above reaction. What is the effect of adding water to a clear saturated of  $I_2$  in the KI solution ?
- **18.** A mixture of  $N_2 \& H_2$  are in equilibrium at 600 K at a total pressure of 80 atm. If the initial ratio of  $N_2$  and  $H_2$  are 3 : 1 and at equilibrium  $NH_3$  is 10% by volume, calculate  $K_p$  of reaction at given temperature.
- **19.**  $\Delta G^{\circ}$  (298 K) for the reaction  $1/2N_2 + 3H_2 \oplus \mathbb{H}_2$   $NH_3$  is -16.5 kJ mol<sup>-1</sup>. Find the equilibrium constant (K<sub>1</sub>) at 25°C. What will be the equilibrium constants K<sub>2</sub> and K<sub>3</sub> for the following reactions :
  - $N_2 + 3H_2 = 120$   $2NH_3$

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 $NH_3 = H_2^{K_3} = 1/2 N_2 + 3/2 H_2$ 

**20.** When NO &  $NO_2$  are mixed, the following equilibria are readily obtained ;

 $2NO_{2} \blacksquare \blacksquare \blacksquare N_{2}O_{4} \qquad \qquad K_{p} = 6.8 \text{ atm}^{-1}$  $NO + NO_{2} \blacksquare \blacksquare N_{2}O_{3} \qquad \qquad K_{p} = ?$ 

In an experiment when NO & NO<sub>2</sub> are mixed in the ratio of 1:2, the total final pressure was 5.05 atm & the partial pressure of  $N_2O_4$  was 1.7 atm. Calculate :

(a) the equilibrium partial pressure of NO. (b)  $K_p$  for NO + NO<sub>2</sub>  $\square \square \square \square \square \square \square \square \square \square \square$ 

21.	Solid $NH_4I$ on rapid heating in a closed vessel at 357°C develops a constant pressure of 275 mm Hg owing to partial decomposition of $NH_4I$ into $NH_3$ and HI but the pressure gradually increases further (when the excess solid residue remains in the vessel) owing to the dissociation of HI. Calculate the final pressure developed at equilibrium
	NH I(s) $\Box \Box \Box \Box$ NH (a) + HI(a)
	$2HI(g) = H_2(g) + I_2(g), K_2 = 0.065 \text{ at } 357^{\circ}\text{C}$
22.	For the reaction SO <sub>2</sub> (g) + 1/2O <sub>2</sub> (g) $\square \square \square$ SO <sub>3</sub> (g) $\Delta H^{\circ}_{298} = -98.32$ kJ/mole,
	$\Delta S_{298}^{\circ} = -95.0 \text{ J/K/mole}$ . Find the K <sub>p</sub> for this reaction at 298 K.
23.	Given are the following standard free energies of formation at 298 K. $CO(g)$ $CO_{a}(g)$ $H_{a}O(g)$ $H_{a}O(l)$
	$\Delta_{\rm f} {\rm G}^{\circ}/{\rm kJ} {\rm mole}^{-1}$ -137.17 -394.36 -228.57 -237.13
	(a) Find $\Delta_{r}G^{\circ}$ and the standard equilibrium constant $K_{p}^{0}$ at 298 K for the reaction
	$CO(g) + H_2O(g) = \bigoplus CO_2(g) + H_2(g)$
	(b) If CO, $CO_2$ and $H_2$ are mixed so that the partial pressure of each is 101.325 kPa and the mixture is brought into contact with excess of liquid water, what will be the partial pressure of each gas when equilibrium is attained at 298 K. The volume available to the gases is constant.
24.	For the reaction
	$C_2H_6$ (g) $\exists \Box \Box = C_2H_4$ (g) + H_2(g)
	$K_p^{\ 0}$ is 0.05 and $\Delta_r G^\circ$ is 22.384 kJ mol <sup>-1</sup> at 900 K. If an initial mixture comprising 20 mol of $C_2 H_6$ and 80 mol of $N_2$ (inert) is passed over a dehydrogenation catalyst at 900 K, what is the equilibrium percentage composition of the effluent gas mixture? The total pressure is kept at 0.5 bar. Given : $\Delta_r S^\circ = 135.143 \text{ J K}^{-1} \text{ mol}^{-1}$ at 300 K. Calculate $\Delta_r G^\circ$ at 300 K. (Assume $\Delta_r C_p = 0$ ).

BRAIN STORMING SUBJECTIVE EXER	CISE ANSWER KEY	EXERCISE-4(B)
<b>1</b> . (i) $k_c = 187.85 \text{ mol}^{-2} \text{ lit}^2$ , $k_p = 0$ .	$05 \text{ atm}^{-2}$ (ii) $P = 12.438 \text{ atm}$	
<b>2.</b> $K_{P_1} = \frac{1}{20P_0^2}, \ K_{P_2} = \frac{3}{20P_0}$		
<b>3.</b> (a) $2.31 \text{ H} 10^{-4}$ (b) (i) decrease	(ii) no change (iii) increase (iv) incre	ease (v) no change (vi) increase
<b>4.</b> 28.8	<b>5.</b> 12.8	<b>6.</b> 0.379 atm
7. (i) $p(CO_2) = 0.938$ atm (ii) $P_{Total} =$	0.68atm <b>8.</b> $P_{NO_2} = 0.64$ atm, $P_{N_2O_4}$	= 0.095 atm
9. $V = 144 \text{ mL}$	<b>10.</b> $k_c = 54$ , $n_{HI} = 0.9$ mol	, $n_{H_2} = 0.05 \text{ mol}, n_{H_2} = 0.3 \text{ mol}$
<b>11.</b> $n_{CO_2} = 0.938$ , $n_{H_2} = 1.938$ , $n_{CO} =$	= 0.062, $n_{H_{2}O} = 4.062$	<b>12.</b> 6.3 Ч 10 <sup>-4</sup>
<b>13.</b> (a) 400 mm <sup>2</sup> , 900 mm <sup>2</sup> (b) $4:9$	9 (c) 72.11 mmHg	<b>14.</b> $\alpha = 0.5$
<b>15.</b> $\Delta_{\rm r} {\rm H} = 75.68 ~{\rm kJ} ~{\rm mol}^{-1}$		<b>16.</b> $k = 2.58$
<b>17.</b> $K = 707.2$ backward reaction is fa	avoured	<b>18.</b> 1.032 Ч 10 <sup>-3</sup>
<b>19.</b> $K_1 = 779.4, K_2 = 6.074 \text{ U} 10^5; K_3$	$= 1.283 \text{ H} 10^{-3}$	
<b>20.</b> (a) 1.05 atm (b) 3.43 atm <sup>-1</sup>		<b>21</b> . 337 mmHg
<b>22.</b> $K_p = 1.862 \text{ H} 10^{12} \text{ atm}^{-1/2}$		
<b>23.</b> (a) $\Delta G^{\circ} = -28.62 \text{ kJ/mole}$ (b) $P_{CO}$	$_{2} = 202.44 \text{ kPa}, P_{H_{2}O} = 3.16 \text{ kPa}, P_{CO}$	= 0.2 kPa, $K_p = 1.039 \text{ H} 10^5$
<b>24.</b> 103.47 kJ/mol		

# EXERCISE - 05 [A]

E –

## JEE-[MAINS] : PREVIOUS YEAR QUESTIONS

1.	Reaction $CO_{(g)} + \frac{1}{2}O_{2(g)}$	) <u> </u>	e of $\frac{K_P}{K_c}$ is -		[AIEEE-2002]
	(A) $\frac{1}{\text{RT}}$	(B) <sub>\(\begin{subarray}{c} RT \) (B) (B) (B) (B) (B) (B) (B) (B) (B) (B</sub>	(C) $\frac{1}{\sqrt{\text{RT}}}$ (D) RT		
2.	One of the following equ (A) $PCl_5(g) \longrightarrow PCl_3(g)$ (C) $N_2(g) + O_2 \longrightarrow 21$	ilibrium is not affected by g) + Cl <sub>2</sub> (g) NO(g)	change in volume of th (B) N <sub>2</sub> (g) + 3H <sub>2</sub> (g) = (D) SO <sub>2</sub> Cl <sub>2</sub> (g) =	ne flask - 2NH <sub>3</sub> (g) SO <sub>2</sub> (g) + Cl <sub>2</sub> (g)	[AIEEE-2002]
3.	For the reaction equilibri $N_2O_4$ (g) $\longrightarrow$ 2NO 1.2 $ H 10^{-2} mol L^{-1} resp$ (A) 3 $ H 10^{-3} mol L^{-1}$	um, <sub>2</sub> (g) the concentration vectively. The value of K <sub>C</sub> (B) 3 Y 10 <sup>3</sup> mol L <sup>-1</sup>	of $N_2O_4$ and $NO_2$ at for the reaction is- (C) 3.3 H $10^2$ mol L <sup>-1</sup>	equilibrium are 4.8 (D) 3 Y 10 <sup>-1</sup> mol I	3
4.	Consider the reaction eq 2SO <sub>2(g)</sub> +O <sub>2(g)</sub> $\longrightarrow$ 2 S On the basis of Le-Chate (A) Lowering the temper (B) Any value of temper (C) Lowering of temperation (D) Increasing temperation	uilibrium $SO_{3(g)}$ ; $\Delta H^{\circ} = -198 \text{ kJ}$ elier's principle, the conditional rature and increasing the stature as well as pressure ature as well as pressure the as well as pressure the stature as well as pressure as well as presse as well as pressure as well as pressure a	ion favourable for the f pressure	orward reaction is -	[AIEEE-2003]
5.	What is the equilibrium e (A) $K_{C} = [P_{4}O_{10}] / [P_{4}] [O_{10}] (C) K_{C} = [O_{2}]^{5}$	xpression for the reactior 21 <sup>5</sup>	$ P_{4(s)} + 5O_{2(g)} = F $ (B) $K_{C} = [P_{4}O_{10}] / 5 [F] $ (D) $K_{C} = 1 / [O_{2}]^{5} $	$P_4O_{10(s)}?$ $P_4][O_2]$	[AIEEE-2004]
6.	For the reaction $CO_{(g)}$ +	$\operatorname{Cl}_{2(g)}$ $\longrightarrow$ $\operatorname{COCl}_{2(g)}$ the	$e~\frac{K_{\rm P}}{K_{\rm C}}~$ is equal to -		[AIEEE-2004]
	(A) $\frac{1}{\text{RT}}$	(B) RT	(C) \sqrt{RT}	(D) 1.0	
7.	The equilibrium constant	for the reaction $N_{2(g)} + O_{2}$	$_{2(g)}$ $\longrightarrow$ $2NO_{(g)}$ at ter	nperature T is 4 4 10 <sup>-</sup>	<sup>-4</sup> . The value of
	$\mathrm{K}_{\mathrm{C}}$ for the reaction $\mathrm{NO}_{\mathrm{(g)}}$	$= \frac{1}{2}N_{2(g)} + \frac{1}{2}O_{2(g)}$	)		[AIEEE-2004]
	(A) 2.5 H 10 <sup>2</sup>	(B) 50	(C) 4 Y 10 <sup>-4</sup>	(D) 0.02	
8.	For the reaction $2NO_{2(g)}$ : $k_c$ are compared at $184^\circ$ (A) $K_p$ is less than $K_c$ (B) $K_p$ is greater than $K_c$ (C) Whether $K_p$ is greater (D) $K_p = K_c$	$2NO_{(g)} + O_{2(g)}$ , (K <sub>c</sub> ) C it is found that even than, less than or equation	= 1.8 Y 10 <sup>-6</sup> at 184° C l to K <sub>c</sub> depends upon tl	C) (R = 0.831 kJ(mol.K ne total gas pressure	()) When K <sub>p</sub> and [AIEEE-2005]
9.	The exothermic formatic $Cl_{2(g)} + 3F_{2(g)} \longrightarrow 2C$ Which of the following w (A) Removing $Cl_2$ (C) Adding $F_2$	on of $ClF_3$ is represented $lF_{3(g)}$ ; $\Delta H_r = -329 \text{ kJ}$ ill increase the quantity of	by the equation CIF <sub>3</sub> in an equilibrium (B) Increasing the tem (D) Increasing the volu	mixture of Cl <sub>2</sub> , F <sub>2</sub> and perature Ime of the container	[AIEEE-2005] I CIF <sub>3</sub> ?

10. A schematic plot of  $ln K_{eq}$  verus inverse of temperature for a reaction is shown below. The reaction must be [AIEEE-2005]

(A) endothermic

(B) exothermic

11.

- (C) highly spontaneous at ordinary temperature
- (D) one with negligible enthalpy change



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

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

ℓ<sub>n</sub> K<sub>eq</sub>

 $1.5 \text{ H}10^{-3} \text{ 1/T (K}^{-1})$ 

2.0 Y10<sup>3</sup>

 $(A)\left(\frac{2x}{1-x}\right)P \qquad (B)\left(\frac{x}{x-1}\right)P \qquad (C)\left(\frac{x}{1-x}\right)P \qquad (D)\left(\frac{x}{x+1}\right)P$ 

**12.** The equilibrium constant for the reaction  $SO_3(g) \longrightarrow SO_2(g) + \frac{1}{2}O_2(g)$  is  $K_c = 4.9410^{-2}$ . The value of  $K_c$  for the reaction [AIEEE-2006]

 $2SO_{2}(g) + O_{2}(g) = 2SO_{3}(g) \text{ will be}$ (A) 2.40  $H 10^{-3}$  (B) 9.8  $H 10^{-2}$  (C) 4.9  $H 10^{-2}$  (D) 416

13. The equilibrium constants K<sub>p1</sub> and K<sub>p2</sub> for the reaction X 2 2Y and Z 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 pressure at these equilibria is [AIEEE-2008]
(A) 1 : 36 (B) 1 : 1 (C) 1 : 3 (D) 1 : 9

14. 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 :-

[AIEEE-2011]

[AIEEE-2012]

- (A) 0.3 atm (B) 0.18 atm (C) 1.8 atm (D) 3 atm
- **15.** The equilibrium constant (K<sub>C</sub>) for the reaction  $N_2(g) + O_2(g) \longrightarrow 2NO(g)$  at temperature T is

4 Y 10<sup>-4</sup>. The value of K<sub>C</sub> for the reaction. NO(g)  $\longrightarrow \frac{1}{2}N_2(g) + \frac{1}{2}O_2(g)$  at the same temperature is :-

(A) 50.0	(B) 0.02	(C) 2.5 Y 10 <sup>2</sup>	(D) 4 Y 10-4

JEE-[MAIN] : PREVIOUS YEAR QUESTIONS						is į	ANSWER KEY			EXERCISE -5[A]					
Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans	С	С	А	А	D	А	В	В	С	В	D	D	А	С	А

[AIEEE-2006]

## **EXERCISE - 05 [B]**

## JEE-[ADVANCED] : PREVIOUS YEAR QUESTIONS

- **1.** For the reaction CO (g) +  $H_2O = \bigoplus CO_2(g) + H_2(g)$  at a given temperature the equilibrium amount of
  - $\rm{CO}_2$  (g) can be increased by :
  - (A) adding a suitable catalyst
  - (B) adding an inert gas
  - (C) decreasing the volume of the container
  - (D) increasing the amount of CO (g)
- 2. For the reaction,  $N_2O_5(g) = 2 NO_2(g) + 0.5 O_2(g)$ , calculate the mole fraction of  $N_2O_5(g)$  decomposed at a constant volume & temperature, if the initial pressure is 600 mm Hg & the pressure at anytime is 960 mm Hg. Assume ideal gas behaviour. [JEE 1998]
- The degree of dissociation is 0.4 at 400 K & 1.0 atm for the gaseous reaction PCl<sub>5</sub> I Im PCl<sub>3</sub> + Cl<sub>2</sub>(g). Assuming ideal behaviour of all gases. Calculate the density of equilibrium mixture at 400 K & 1.0 atm pressure.
   [JEE 1999]
- 4. When 3.06 g of solid  $\text{NH}_4\text{HS}$  is introduced into a two litre evacuated flask at 27°C, 30% of the solid decomposes into gaseous ammonia and hydrogen sulphide. [JEE 2000]

(i) Calculate  $K_{c} \& K_{p}$  for the reaction at 27°C.

(ii) What would happen to the equilibrium when more solid  $NH_4HS$  is introduced into the flask?

5. When 1-pentyne (A) is treated with 4N alcoholic KOH at  $175^{\circ}$ C, it is converted slowly into an equilibrium mixture of 1.3% 1-pentyne (A), 95.2% 2-pentyne (B) & 3.5 % of 1,2-pentadiene (C). The equilibrium was maintained at  $175^{\circ}$ C. Calculate  $\Delta G^{\circ}$  for the following equilibria.

 $B = A \qquad \Delta G_1^{\circ} = ?$  $B = C \qquad \Delta G_2^{\circ} = ?$ 

From the calculated value of  $\Delta G_1^{\circ} \& \Delta G_2^{\circ}$  indicate the order of stability of A, B & C. Write a reasonable reaction mechanism sharing all intermediate leading to A, B & C. [JEE 2001]

6.  $N_2O_4$  (g)  $A = 2NO_2$  (g)

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This reaction is carried out at 298 K and 20 bar. 5 mol each of  $N_2O_4$  and  $NO_2$  are taken initially :

Given :  $\Delta G^{\circ}_{N_2O_4} = 100 \text{ kJ mol}^{-1}$ ;  $\Delta G^{\circ}_{NO_2} = 50 \text{ kJ mol}^{-1}$ 

- (i) Find  $\Delta G$  for reaction at 298 K under given condition.
- (ii) Find the direction in which the reaction proceeds to achieve equilibrium. [JEE 2004]

[JEE 1998]

7.  $N_2 + 3H_2 = 2NH_3$ 

8.

Which is correct statement if N2 is added at equilibrium condition?

- (A) The equilibrium will shift to forward direction because according to II law of thermodynamics the entropy must increases in the direction of spontaneous reaction.
- (B) The condition for equilibrium is  $G_{N_2} + 3G_{H_2} \oplus \oplus 2 G_{NH_3}$  where G is Gibbs free energy per mole of the gaseous species measured at that partial pressure. The condition of equilibrium is unaffected by the use of catalyst, which increases the rate of both the forward and backward reactions to the same extent.

(C) The catalyst will increase the rate of forward reaction by  $\alpha$  and that of backward reaction by  $\beta.$ 

- (D) Catalyst will not alter the rate of either of the reaction. [JEE 2006]
- The value of  $\log_{10}$ K for a reaction A  $\square \square \square$  B is : [JEE 2007]

(Given :  $\Delta_r H^{\circ}_{_{298K}} = -54.07 \text{ kJ mol}^{-1}$ ,  $\Delta_r S^{\circ}_{_{298K}} = 10 \text{ JK}^{-1} \text{ mol}^{-1}$  and

 $R=8.314\ JK^{-1}mol^{-1}\,;\,2.303\ 4\,8.314\ 4\,298=5705)$ 

JEE-[/	ADVANICE]	PREVIOUS YEAR QUESTIONS	ANSWER KEY	EXERCISE -5[B]						
1.	D	<b>2</b> . Fraction decomp	osed = 0.4	<b>3.</b> 4.54 g dm <sup>-3</sup>						
4.	(i) $K^{}_{\rm C} = 8.1~{\rm H}~10^{-5}~{\rm mol}^2~L^2$ ; $K^{}_{\rm P} = 4.91~{\rm H}~10^{-2}~{\rm atm}^2$ ,(ii) No effect ;									
5.	15991 J mol <sup>-1</sup> , 12304 J mol <sup>-1</sup> ; $B > C > A$									
6.	(i)	(i) $5.705 \text{ H}  10^3 \text{ J}  \text{mol}^{-1}$								
	(ii)	Since initial Gibbs free energy change of the reaction is positive, so the reverse reaction will								
		take place.								
7.	В									
8.	В									
		$\Delta G^{\circ} \qquad = \Delta H^{\circ} - T \Delta S^{\circ}$								
		= - 54.07 Y 1000 - 298 Y 10								
		= -54070 - 2980 = -57050								
		$\Delta G^{\circ} = -2.303 \text{ RT } \log_{10}$	K							
	$-57050 = -2.303 \text{ Y} 298 \text{ Y} 8.314 \log_{10} \text{K}$									
		$= -5705 \log_{10} K$								
		log10 K = 10								