

Level-01

Chemical Equilibrium.

Answer. 2 We know that, $K_c \text{ unit} = (\text{conc})^{\Delta n}$

where, $\Delta n = \left(\text{Total moles of product} \right) - \left(\text{Total moles of reactant} \right)$

for homogeneous reaction.

For reaction, $A + B \rightleftharpoons C$, unit of K_c should be $\left(\frac{\text{mol}}{\text{litre}} \right)^{-1}$ i.e. $\left(\frac{\text{litre}}{\text{mol}} \right)$.

Answer. 3

$$\Delta n = (4+6) - (4+5) = 1$$

So, unit of $K_c = (\text{conc})^{+1}$

Answer. 4

Equilibrium constant does not change with change in concentrations, pressure and volume. It only changes with temperature and stoichiometry of the reaction.

Answer. 5

If for a chemical reaction, equilibrium constant is K , then the equilibrium constant for the reaction obtained by multiplying a number 'n' with the original equation will be $(K)^n$.



Answer. 6 (i) Since ΔH is (-)ve, therefore the reaction is an exothermic reaction and thus the reaction will go backward on increasing the temperature.

(ii) On decreasing the pressure, the reaction will go in direction of more number of moles, so in this case the reaction will go in backward direction.

(iii) Removal of ~~the~~ reactant will result in ~~the~~ backward reaction.

(iv.) Addition of product will favour backward reaction.

Answer. 7 An ion exchange reaction with all reactants and products in same phase.

Answer. 8 Addition or removal of solid species will not affect the equilibrium. Since, it is a dissociation reaction, hence it must be endothermic, and thus increase in temperature favours forward reaction.

Answer. 9 For dissociation of PCl_5 , the formula for degree of dissociation will be,

$$\alpha = \frac{D_{\text{theoretical}} - D_{\text{observed}}}{D_{\text{observed}}}$$

$$= \frac{104.16 - 62}{62}$$

$$= 0.68$$

So, degree of dissociation is 68%.

Answer.11

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

Here, $\Delta n = 1 - (1+1) = -1$

So, $K_p = 26 (0.0821 \times 523)^{-1} = 0.61$

Answer.12



At equilibrium, $[CO] = \frac{0.1}{\frac{1}{2}} = 0.2$

$$[Cl_2] = \frac{0.1}{\frac{1}{2}} = 0.2$$

$$[COCl_2] = \frac{0.3}{\frac{1}{2}} = 0.6$$

So,

$$K_c = \frac{[COCl_2]}{[CO][Cl_2]} = \frac{0.6}{(0.2)^2} = 15$$

Answer.13

Lower the value of K , less will be tendency of the reaction to go forward and thus higher the stability of Oxide. In this case, NO_2 will be most stable oxide of nitrogen.

Answer.14



Initial,

1

0

0

At eqm,

$1-x$

$\frac{x}{2}$

$\frac{x}{2}$

Given that, $x = 0.22$, thus,

$1-0.22$

$\frac{0.22}{2}$

$\frac{0.22}{2}$

At eqm,

0.78

0.11

0.11

$$K_c = \frac{[H_2][I_2]}{[HI]^2} = \left(\frac{0.11}{0.78}\right)^2 = 0.0199$$

Answer. 15 Initial concentration of $\text{PCl}_5 = \frac{2}{2} = 1 \text{ M}$



$$1 \quad \quad \quad 0 \quad 0$$

$$1-x \quad \quad \quad x \quad x$$

Given, $x = 0.4$

$$1-0.4 \quad \quad \quad 0.4 \quad 0.4$$

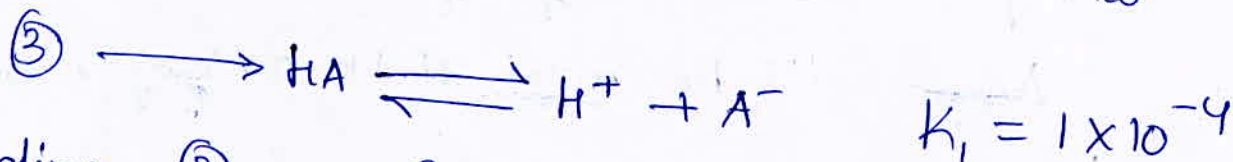
$$0.6 \quad \quad \quad 0.4 \quad 0.4$$

$$K_c = \frac{(0.4)(0.4)}{0.6} = 0.267$$

Answer. 16



Answer. 19



Adding $\textcircled{2}$ and $\textcircled{3}$, we get equation, thus,

$$K = \frac{K_1}{K_w} = \frac{10^{-4}}{10^{-14}} = 10^{10}$$

Answer. 21

In a reaction with $\Delta n = 0$, the equilibrium remains unaffected by pressure change.

Answer. 22

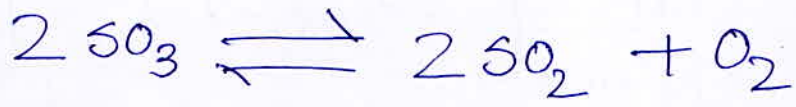


initial moles 1 0
At eqm, $1-x$ $2x$

$$\text{Total moles at eqm} = 1-x+2x = 1+x$$

$$\text{So, partial pressure of } \text{N}_2\text{O}_4 \text{ at eqm} = \left(\frac{1-x}{1+x}\right) \times P$$

Answer. 25



Initial,	1	0	0
At equilibrium,	$1-2x$	$2x$	x

Given that, $2x = 0.6 \Rightarrow \boxed{x = 0.3}$
 Then,

$1 - 0.6$ $= 0.4$	0.6	0.3
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$$K_c = \frac{(0.6)^2 \times 0.3}{(0.4)^2} = 0.675$$

Answer. 30

Reaction with Δn (+ve) will be favoured at low pressure.

Answer. 31

Value of K_c should be given as 4 to satisfy the answer given in the booklet.

Initial,	CH_3COOH	$+ \text{C}_2\text{H}_5\text{OH}$	\rightleftharpoons	$\text{CH}_3\text{COOC}_2\text{H}_5$	$+ \text{H}_2\text{O}$
	1	1		0	0
Equilibrium,	$1-x$	$1-x$		x	x

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

$$\Rightarrow 2 = \frac{x}{1-x} \Rightarrow \boxed{x = \frac{2}{3}}$$

Answer. 36

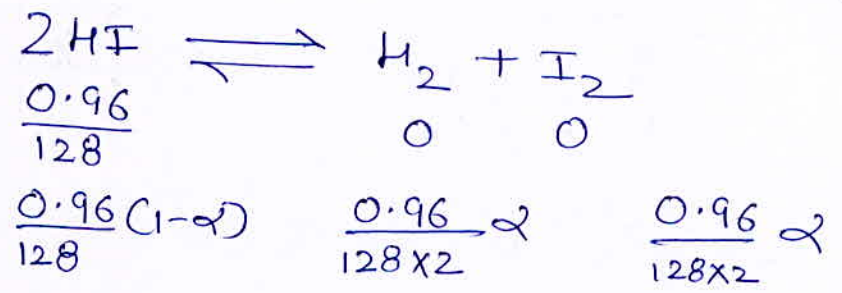
According to the formula, $K_p = K_c (RT)^{\Delta n}$
 K_p will be less than K_c when Δn is (-ve).

Answer. 38

Rate of decomposition of gas = $K_f [\text{Gas}]$
 $= 1 \times 10^{-4} \times 5 \times 10^{-2}$
 $= 5 \times 10^{-6} \frac{\text{mol}}{\text{min litre}}$

Answer. 40

Initial moles,
At equilibrium,



Now, milliequivalents of $\text{Na}_2\text{S}_2\text{O}_3 = 14 \times \frac{1}{10} = 1.4$
 Equivalents of $\text{Na}_2\text{S}_2\text{O}_3 = 1.4 \times 10^{-3}$

According to the law of equivalence, equivalents of I_2 should be equal to equivalents of $\text{Na}_2\text{S}_2\text{O}_3$.

So, Equivalents of $\text{I}_2 = 1.4 \times 10^{-3}$
 no. of moles of $\text{I}_2 = \frac{1.4 \times 10^{-3}}{2}$

So, $\frac{0.96}{128 \times 2} \alpha = \frac{1.4 \times 10^{-3}}{2} \Rightarrow \alpha = 18.6\%$

Answer. 41



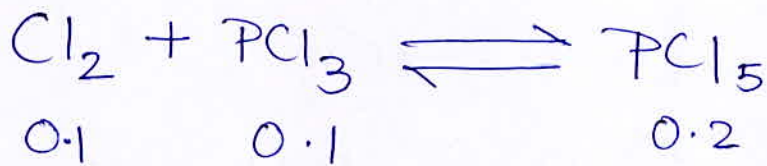
Initial moles,
At equilibrium,
Concentration



$$K = \frac{\left(\frac{x}{2}\right)^2}{\left(\frac{a-x}{2}\right)\left(\frac{b-x}{2}\right)} = \frac{x^2}{(a-x)(b-x)}$$

Answer. 42 Since N_2 will not react with any of the gases in the mixture, therefore it is an inert gas with respect to the given reaction. Now, addition of inert gas at constant pressure will result in an increase in volume, thus the reaction will go in direction of more no. of moles. So, reaction will go in forward direction with $\alpha > 0.2$.

Answer. 43



$$K_p = \frac{0.2}{(0.1)^2}$$

For new equilibrium, $K_p = \frac{p_{PCl_5}}{(p_{PCl_3})(p_{Cl_2})}$

$$\Rightarrow \frac{0.2}{(0.1)^2} = \frac{p_{PCl_5}}{\left(\frac{0.1}{2}\right)\left(\frac{0.1}{2}\right)}$$

$$\Rightarrow \frac{0.2}{(0.1)^2} = \frac{4 p_{PCl_5}}{(0.1)^2}$$

$$\Rightarrow \boxed{p_{PCl_5} = \left(\frac{1}{4}\right) 0.2}$$

So, partial pressure of PCl_5 is $\frac{1}{4}$ times of the p_{PCl_5} in the first experiment.

Answer. 44

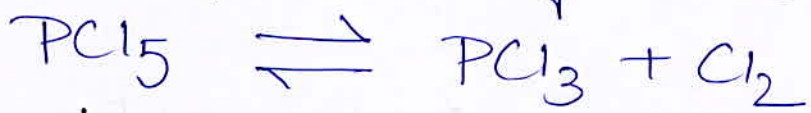


Initial moles,
At equilibrium,

	1	0	0
	$1 - \alpha_1$	α_1	α_1
Concentration,	$\frac{1 - \alpha_1}{V_1}$	$\frac{\alpha_1}{V_1}$	$\frac{\alpha_1}{V_1}$

$$K_c = \frac{\left(\frac{\alpha_1}{V_1}\right) \left(\frac{\alpha_1}{V_1}\right)}{\left(\frac{1 - \alpha_1}{V_1}\right)} = \frac{\alpha_1^2}{V_1(1 - \alpha_1)}$$

Now, after volume is doubled, the reaction will move in the direction of more no. of moles. So,



Initial moles,
At equilibrium,
Concentration,

	1	0	0
	$1 - \alpha_2$	α_2	α_2
	$\frac{1 - \alpha_2}{2V_1}$	$\frac{\alpha_2}{2V_1}$	$\frac{\alpha_2}{2V_1}$

$$K_c = \frac{\left(\frac{\alpha_2}{2V_1}\right) \left(\frac{\alpha_2}{2V_1}\right)}{\left(\frac{1 - \alpha_2}{2V_1}\right)} = \frac{\alpha_2^2}{2V_1(1 - \alpha_2)}$$

Given that α_1 and α_2 are very small, so, $1 - \alpha_1 \approx \alpha_1$ and $1 - \alpha_2 \approx \alpha_2$. Then,

$$\frac{\alpha_1^2}{V_1} = \frac{\alpha_2^2}{2V_1} \Rightarrow \boxed{\alpha_2 = \sqrt{2} \alpha_1}$$

~~Answer 44~~

Answer. 45



Initial mole,

1 0

At equilibrium,

$1-x$ nx

Total moles at equilibrium = $1-x+nx = 1+(n-1)x$

Due to conservation of mass,

$$M_A \times 1 = M_{(A+B)} \times \{1+(n-1)x\}$$

Dividing this equation by 2, we get,

$$\frac{M_A}{2} \times 1 = \frac{M_{A+B}}{2} \{1+(n-1)x\}$$

$$\Rightarrow \cancel{M_A} D_A \times 1 = D_{(A+B)} \{1+(n-1)x\}$$

$$\Rightarrow D_A = D_{(A+B)} + D_{(A+B)} (n-1)x$$

$$\Rightarrow x = \frac{D_A - D_{(A+B)}}{D_{A+B} (n-1)}$$

Answer. 47



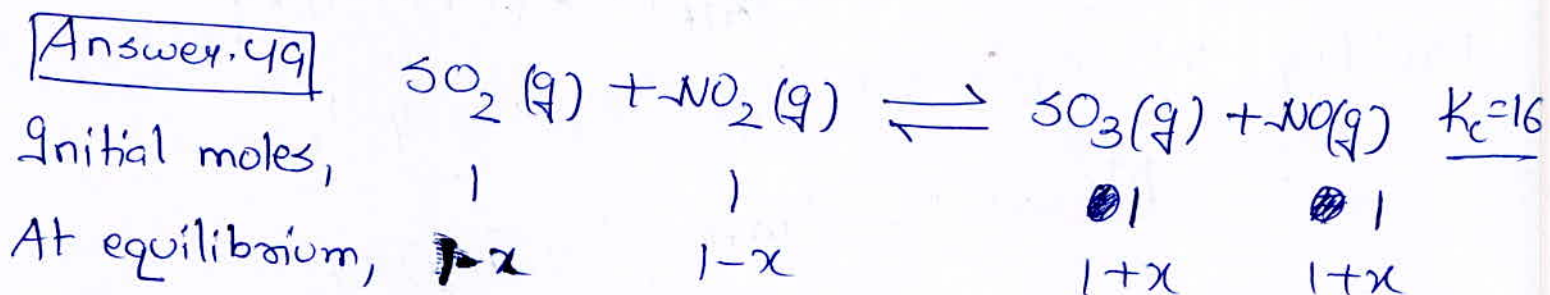
With addition of NH_3 , the reaction will go backward i.e., concentration of reactants will ~~de~~ increase and that of products will ~~inex~~ decrease. Thus, $[Cu(NH_3)_3SO_3]$ would decrease.

Answer, 48



Since the given reaction is an irreversible reaction, hence the addition of BaI_2 will not affect the rate as well as extent of this reaction. According to the stoichiometry of the reaction, the number of moles of $\text{S}_2\text{O}_4^{2-}$ formed at the end of the reaction would be equal to $\frac{1}{2}$ the moles of $\text{S}_2\text{O}_3^{2-}$ reacted.

Answer, 49



$$K_c = \left(\frac{1-x}{1+x}\right)^2 = 16$$

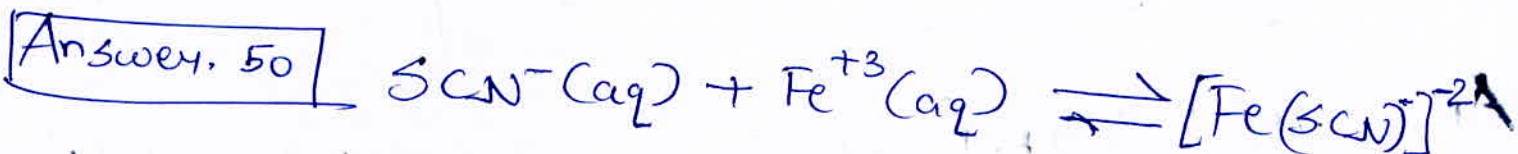
Taking square root on both sides, we get,

$$\frac{1-x}{1+x} = 4 \Rightarrow \underline{x = 0.6}$$

Thus, $[\text{NO}_2] = 1 - 0.6 = 0.4$

$$[\text{NO}] = 1 + 0.6 = 1.6$$

Answer, 50



Addition of reactant SCN^- ion will shift the reaction in forward direction, so more product will be formed. Thus, the solution will become deeper red.

Level - 02

Answer. 3 \downarrow Molar mass of $\text{Urea} (\text{NH}_2\text{CONH}_2) = 60$
 \downarrow Moles of urea = $\frac{120}{60} = 2$ moles
Molarity of urea = $\frac{2}{5} = 0.4 \text{ M}$

An

Answer. 4 $K_p = K_c$, when $\Delta n_g = 0$.

Answer. 5 At low pressure, reaction will move in the direction of more no. of moles.

Answer. 6 $K_p > K_c \Rightarrow \Delta n_g > 0$.

Answer. 7 Since more of product is added, therefore, the reaction should ^{move} towards reactants. Hence, more cis-2-pentene is formed.

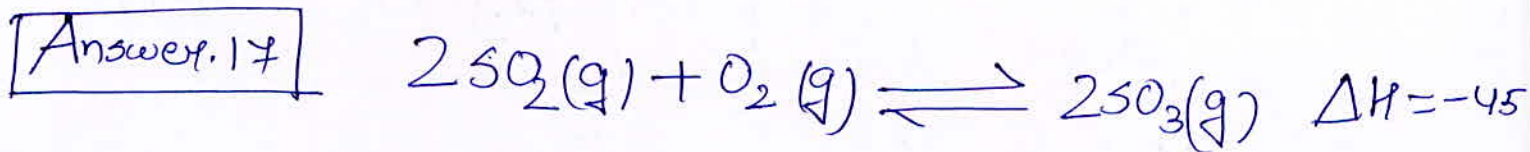
Answer. 9 Value of equilibrium constant will not change with change in volume.

Answer. 12 $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$

Since according to Le-Chatelier's principle, with increase in pressure, the reaction will move in ~~less~~ direction of less no. of ~~molecules~~ moles. So, reaction will move in forward direction.

Answer. 13 Increase in volume results in the movement of reaction in the direction of more number of moles. So, the answer is,



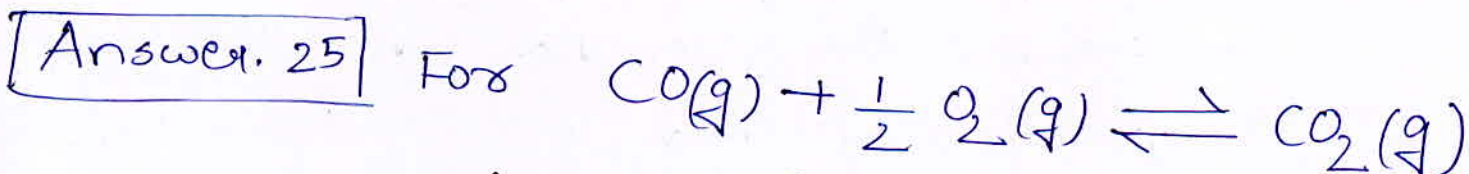
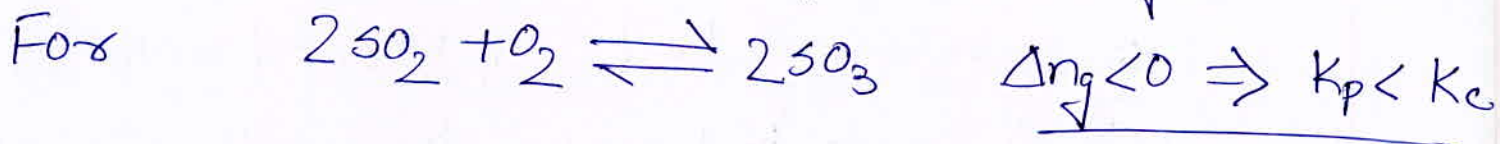
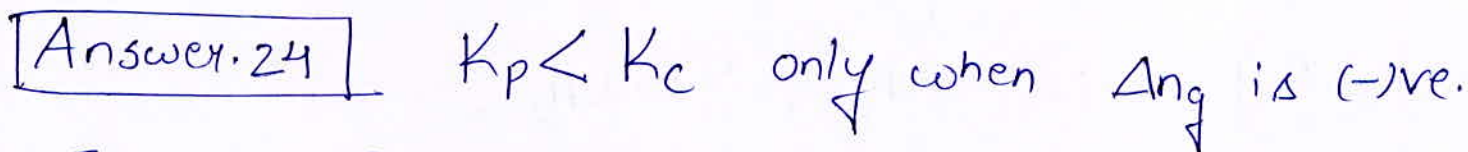


Since it is an exothermic reaction, hence it should be favoured ~~in~~ at low temperature



Answer. 20 There will be no effect of addition of inert gas ~~on the eq~~ at constant volume on the equilibrium.

Answer. 23 Equilibrium constant does not change with concentration of reactants.



$$\Delta n_g = 1 - (1 + \frac{1}{2}) = -\frac{1}{2}$$

$$K_p = K_c (RT)^{\Delta n_g} \Rightarrow \frac{K_p}{K_c} = (RT)^{-\frac{1}{2}}$$

$$\Rightarrow \left| \frac{K_p}{K_c} = \frac{1}{\sqrt{RT}} \right|$$

Self - Practice Question

Answer. 5

The value of equilibrium constant does not depend on the initial concentrations of the reactants.

Answer. 6

If $\Delta n_g \neq 0$, then equilibrium constant unit will depend on the units of concentration. In reaction, $\text{CoCl}_2(\text{g}) \rightleftharpoons \text{Co}(\text{g}) + \text{Cl}_2(\text{g})$

~~$\Delta n_g = 1$~~ $\Delta n_g = 1$, thus the unit of K_c will be $(\text{atm})^1$.

Answer. 7

Greater the value of equilibrium constant, greater will be the tendency of the reaction for completion. Thus, with ~~equi~~ $K = 9 \times 10^{-3}$, production of AB is most favoured.

Answer. 8

Since $\Delta n_g = 0$, therefore there will be no effect of addition of an inert gas or increase of pressure. The degree of dissociation will be affected by increase of temperature.

Answer. 9



Initial concentration, 1M 1M 0

At equilibrium, $1-x$ $1-x$ $2x$

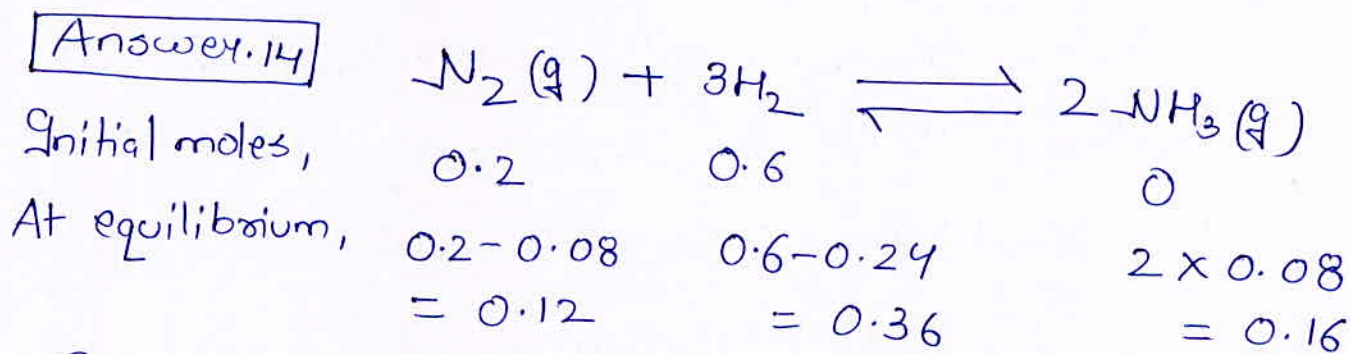
$$K_c = 2 = \left(\frac{2x}{1-x} \right)^2$$

Taking square root on both sides, we get

$$\Rightarrow \sqrt{2} = \frac{2x}{1-x} \Rightarrow \boxed{x = \frac{1}{1+\sqrt{2}}}$$

Answer.10 When a system is compressed, it means pressure is increased. When pressure is increased, according to Le Chatelier's principle, reaction will move in direction of less no. of moles. So, PCl_3 and Cl_2 will combine to form PCl_5 .

Answer.13 Since the value of equilibrium constant is decreasing with increase in temperature, therefore we can say that the reaction is exothermic.



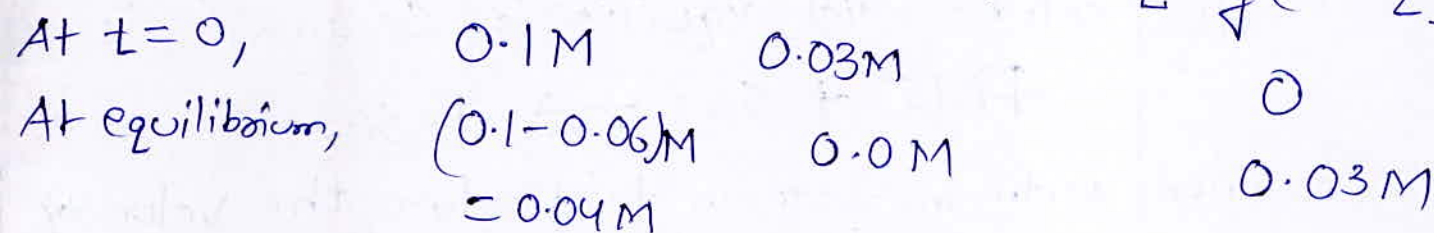
Given that 40% of mixture reacts, it means 0.32 moles of mixture react. So, according to stoichiometry of reaction, 0.08 moles of N_2 and 0.24 moles of H_2 reacts. Now, since temperature and pressure are constant, hence, $V \propto n$. So, volume ratio is same as mole ratio. So,

$$\text{Final moles of gases} = 0.12 + 0.36 + 0.16 = 0.64$$

$$\text{Initial moles of gases} = 0.2 + 0.6 = 0.80$$

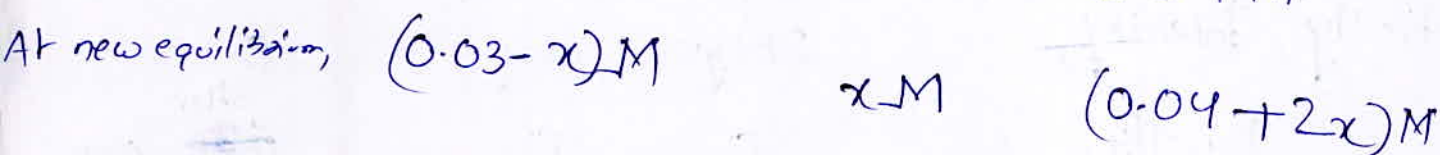
$$\text{So, molar ratio} = \text{Volume ratio} = \frac{0.64}{0.80} = \frac{4}{5}$$

Answer. 15



In this reaction, concentration of Ag^+ is zero, so this equilibrium is shifted towards left.

Hence by dissociation some Ag^+ is formed.



$$K = \frac{[\text{Ag}^+][\text{CN}^-]^2}{[\text{Ag}(\text{CN})_2]^+}$$

Hence, $4 \times 10^{-19} = \frac{x \times (0.04 + 2x)^2}{(0.03 - x)}$

~~0.03~~ where, $0.03 - x \approx 0.03$

So, $4 \times 0.03 \times 10^{-19} = x \times (0.04 + 2x)^2$

$$1.2 \times 10^{-20} = x \times (16 \times 10^{-4} + 4x^2 + 0.16x)$$
$$= (16 \times 10^{-4})x + 4x^3 + 0.16x^2$$

On neglecting the higher power of x ,

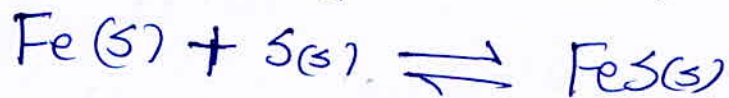
$$16 \times 10^{-4} x = 1.2 \times 10^{-20}$$

$$x = 7.5 \times 10^{-18} \text{ M}$$

Hence,

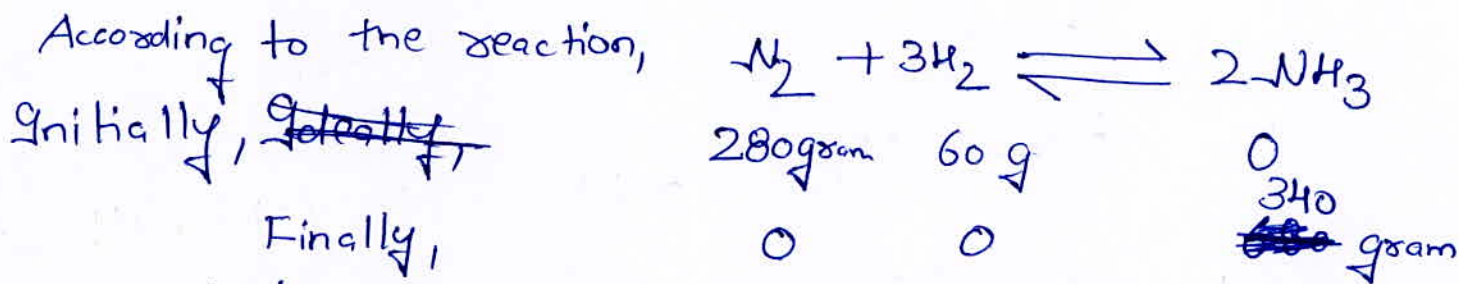
$$[\text{Ag}^+] = 7.5 \times 10^{-18} \text{ M}$$

Answer. 16 Le Chatelier's principle is not applicable to solid-solid equilibria. So, answer is

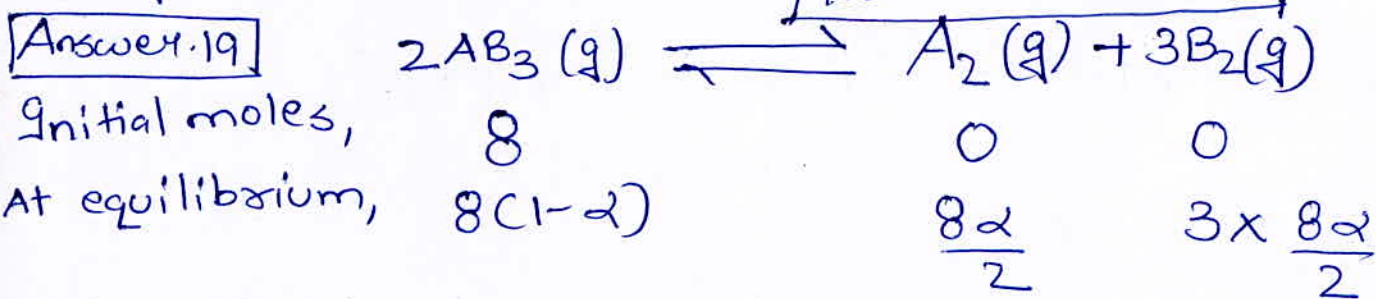


Answer. 17 Since with increase in temperature, the value of K_{eq} is also increasing, hence the reaction is an endothermic reaction.

Answer. 18 Let the mass of N_2 in the mixture be x , then mass of H_2 will be $340 - x$. In right ratio means $(n_{\text{N}_2}) \times 3 = n_{\text{H}_2}$
then, $3 \times \left(\frac{x}{28}\right) = \frac{340 - x}{2} \Rightarrow x = 280 \text{ gram.}$



But it is given that yield is 20%, so the mass of NH_3 produced will $\frac{20}{100} \times 340 = 68 \text{ gram.}$



Given that, $\frac{8\alpha}{2} = 2 \Rightarrow \alpha = \frac{1}{2}$

then, $8(1 - \frac{1}{2}) = 4$ 2 $3 \times \frac{8}{2} \times \frac{1}{2} = 6$

$$K_c = \frac{2 \times (6)^3}{(4)^2} = 27 \text{ mol}^2 \text{ L}^{-2}$$

Answer. 23 moles of O_2 in 5.6 litre of O_2 at STP = $\frac{5.6}{22.4} = 0.25$
So, active mass = $\frac{\text{moles}}{\text{Volume}} = \frac{0.25}{5.6}$

Answer. 24



$$V = 2 \text{ dm}^3 = 111 \text{ liter}$$

Initial moles, 1 2 0

At equilibrium, $1-x$ $2-3x$ $2x$

Given that, $2x = 0.8 \Rightarrow x = 0.4$

So, $[\text{H}_2] = 2 - 3(0.4) = 2 - 1.2 = 0.8$

Answer. 25

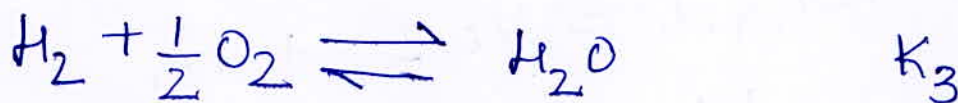
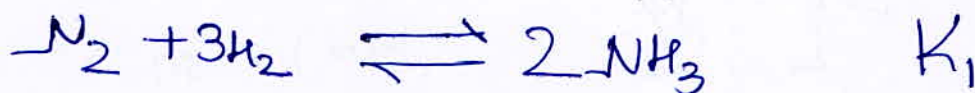


Initial moles, 2 2 0 0

At equilibrium, $2-2x$ $2-x$ $3x$ x

So, $[\text{A}] < [\text{B}]$ at equilibrium

Answer. 27



Reversing reaction ①, multiplying reaction ③ by 3, and adding the resulting reactions with reaction 2, we get the reaction,



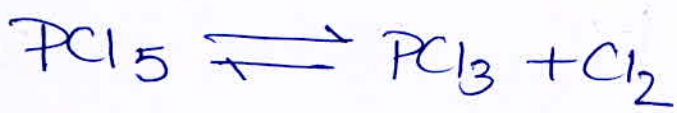
with

$$K = \frac{K_2 K_3^3}{K_1}$$

Answer 29



Answer 31



Initial moles,	1	0	0
At equilibrium,	$1-x$	x	x

Total moles at equilibrium = $1+x$

Let the molar mass of mixture be M_x .

Due to conservation of mass,

~~$(208.5 \times 1) \times 2 = (1+x) \times M_x$~~ $= (1+x) \times M_x$

Dividing this equation by 2, we get,

~~$\frac{208.5}{2} = (1+x) \times \frac{M_x}{2}$~~

~~$104.25 = (1+x) \times d_0$~~ $= (1+x) \times d_0$ $(V \cdot D = \frac{M \cdot n}{2})$

Given that, $d_0 = 70.2$, then,

$104.25 = (1+x) \times (70.2)$

\Rightarrow $x = 0.485$

Answer 33



Initial moles,	1	0
At equilibrium,	$1-x$	$2x$

Given that, $x = 0.4$, then,

$1-0.4$	2×0.4
$= 0.6$	$= 0.8$

Equilibrium concentration, $\frac{0.6}{2} = 0.3$

$\frac{0.8}{2} = 0.4$

$K = \frac{(0.4)^2}{0.3} = 0.53$

Assertion and Reason Questions

Answer. 2

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

So, for reactions where $\Delta n_g \neq 0$,
 $K_p \neq K_c$. At constant temperature,

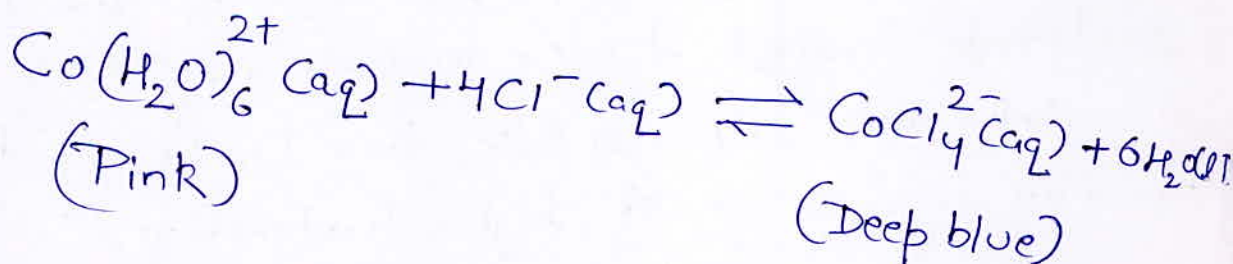
$$P = \left(\frac{nRT}{V} \right) \text{ where}$$

$$\Rightarrow P = CRT \text{ or } \boxed{P \propto C}$$

Answer. 3

We don't take concentrations of solids in K_c expression.

Answer. 4



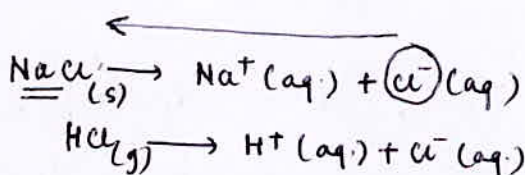
~~For endothermic, K_c depends~~

For endothermic reactions, K_c decreases with decrease in temperature, so reaction moves backward.

Answer. 5

If Q_c (reaction quotient) $<$ K_c (equilibrium constant) reaction moves in direction of products.

Answer. 6



Brine is an aq. dil. NaCl solⁿ.

Since the reaction is not at equilibrium in brine solution, hence Le-Chatelier's principle is not applicable.

Answer. 7 Addition of heat to the equilibrium solid \rightleftharpoons liquid results in decrease in the amount of solid because the reaction is endothermic, and thus heating favours forward reaction.

Answer. 12 For the reaction,



$$\Delta n = (1 + 3) - 2 = 2$$

So, unit of K_p is $(\text{atm})^2$.

Answer. 13 $\log \left(\frac{K_2}{K_1} \right) = - \frac{\Delta H}{2.303 R} \left[\frac{1}{T_2} - \frac{1}{T_1} \right]$ where, $(T_2 > T_1)$

For exothermic ΔH is (-)ve, thus $K_2 < K_1$, which implies reaction is favoured at lower temperature.

For endothermic ΔH is (+)ve, thus $K_2 > K_1$, which implies reaction is favoured at higher temperature.

Answer. 15 There is no relation between ~~the~~ assertion and reason. Reason statement is true because of Le-Chatelier's principle. But in assertion statement there are no gases, ~~so no~~ but water in liquid form. Increase in pressure will favour forward reaction because of decrease in volume in going from ice to water.

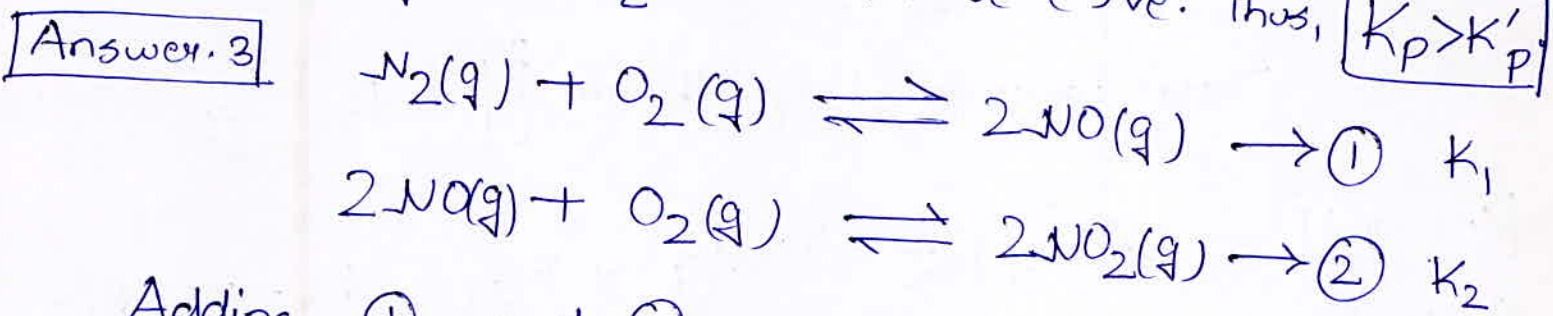
Answer. 16 Since the reaction is exothermic with (-)ve Δn_g , hence forward reaction is favoured at low temperature and high pressure.

Answer. 17 Equilibrium constant is independent of the ~~the~~ volume of the reaction vessel.

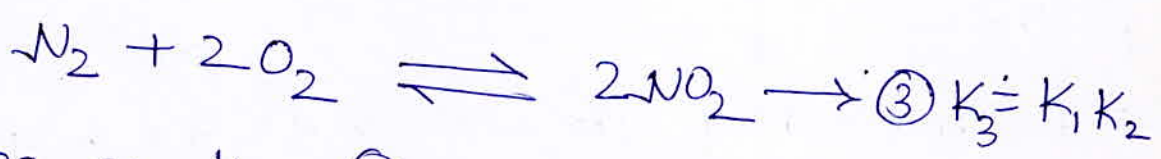
Previous Years Questions

Answer. 2 We have, $\log \left(\frac{K'_p}{K_p} \right) = -\frac{\Delta H}{2.303R} \left[\frac{1}{T_2} - \frac{1}{T_1} \right]$

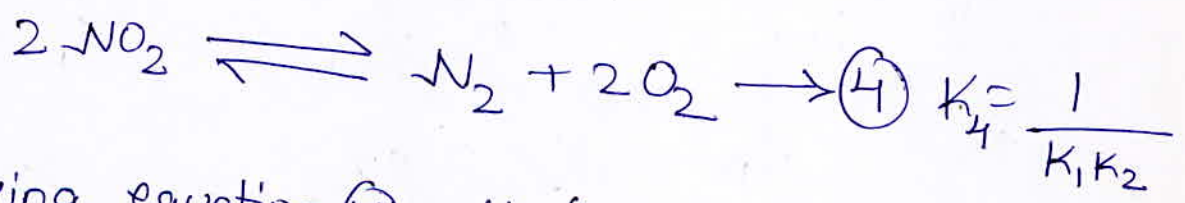
Since the reaction is exothermic, hence $\Delta H = (-ve)$.
 Assuming $T_2 > T_1$, we see that right hand side of this equation will be (-ve). Thus, $K_p > K'_p$



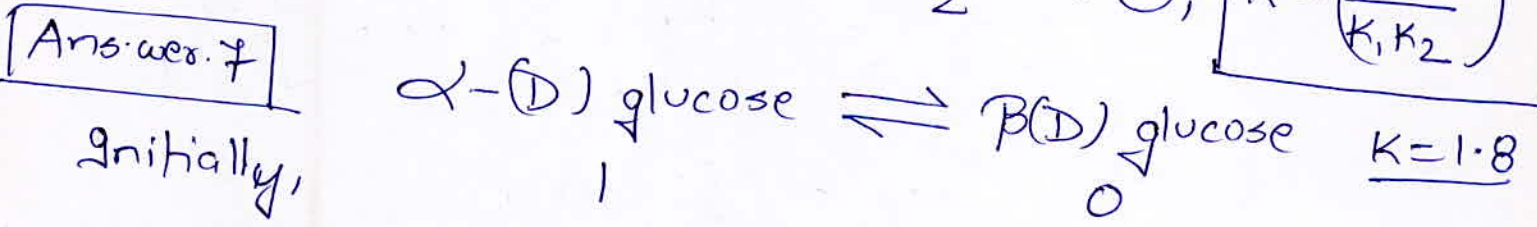
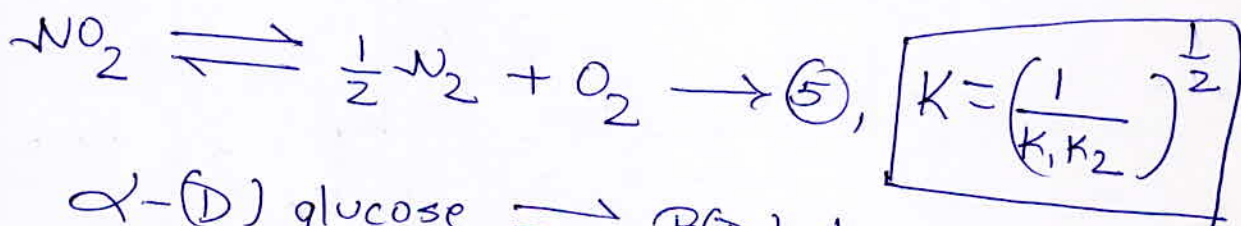
Adding $\textcircled{1}$ and $\textcircled{2}$, we get,



Reversing equation $\textcircled{3}$, we get,



Multiplying equation $\textcircled{4}$ with $\left(\frac{1}{2}\right)$, we get,



Initially,

1

0

At equilibrium,

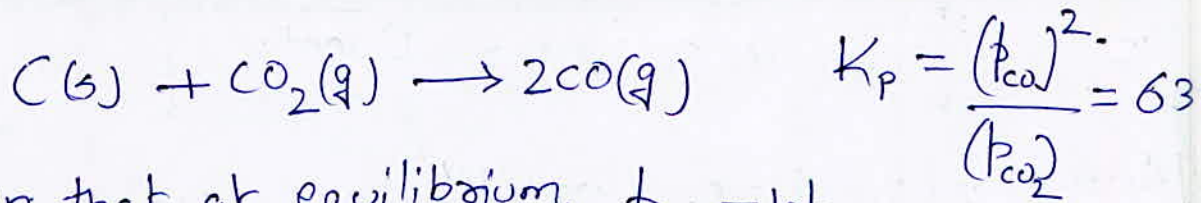
$1-x$

x

So, $K = \frac{x}{1-x} \Rightarrow 1.8 = \frac{x}{1-x} \Rightarrow \boxed{x = 0.643}$

Thus, $1-x = 1-0.643 = 0.357 = 35.7\%$

Answer. 10



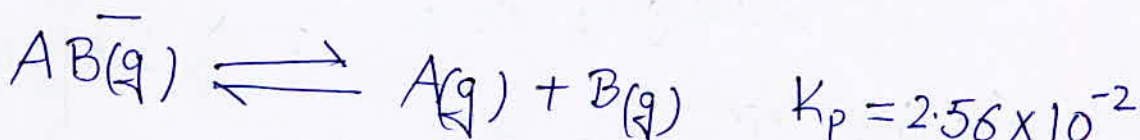
Given that, at equilibrium, $p_{CO} = 10p_{CO_2}$, then,

$$K_p = 63 = \frac{(10p_{CO_2})^2}{(p_{CO_2})} \Rightarrow p_{CO_2} = 0.63 \text{ atm}$$

$$\text{and } p_{CO} = 10 \times 0.63 = 6.3 \text{ atm}$$

$$\text{Total pressure at equilibrium, } \boxed{P = p_{CO} + p_{CO_2} = 6.93 \text{ atm}}$$

Answer. 11



Initial moles, 1 0 0

Equilibrium, $1-x$ x x

$$\text{Total moles at equilibrium} = 1-x + x + x = 1+x$$

$$\text{So, } p_{AB} = \frac{1-x}{1+x}, \quad p_A = \frac{x}{1+x}, \quad p_B = \frac{x}{1+x}$$

$$\text{So, } K_p = \frac{\left(\frac{x}{1+x}\right) \left(\frac{x}{1+x}\right)}{\left(\frac{1-x}{1+x}\right)} = \frac{x^2}{1-x^2}$$

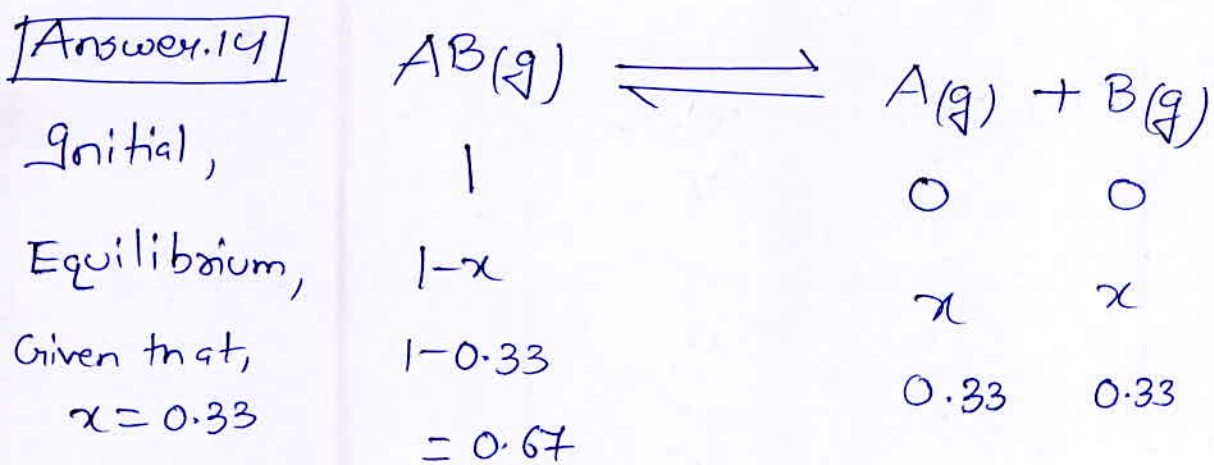
$$\Rightarrow \frac{x^2}{1-x^2} = \frac{K_p}{1+K_p} \Rightarrow x = \sqrt{\frac{K_p}{1+K_p}}$$

$$\Rightarrow x = \sqrt{\frac{2.56 \times 10^{-2}}{1 + 2.56 \times 10^{-2}}}$$

$$\Rightarrow x = 0.16$$

\Rightarrow percentage dissociation $= x = 16\%$

Answer. 12 ~~The~~ Increase in pressure implies that there is an increase in no. of moles of products. Since the concentration of products is greater than reactants, then $K > 1.0$



Total moles at equilibrium = $1 + 0.33 = 1.33$

$$p_{AB} = \frac{0.67}{1.33} p, \quad p_A = p_B = \frac{0.33}{1.33} p$$

$$K_p = \frac{\left(\frac{0.33}{1.33} p\right)^2}{\left(\frac{0.67}{1.33} p\right)} = \frac{(0.33)^2}{1.33 \times 0.67} p$$

$$\Rightarrow K_p \approx \frac{0.1}{0.8} p \Rightarrow \boxed{p = 8K_p}$$

Answer. 16

$$K = \frac{K_f}{K_b} = \frac{2.38 \times 10^{-4}}{8.15 \times 10^{-5}} = 2.92$$

Answer. 19 For given reaction, $\Delta n = -1$

So, $K_p = K_c (RT)^{-1} \Rightarrow K_c = K_p (RT)$

$$\Rightarrow K_c = 2 \times 10^{10} \times (0.0821 \times 450) = 73.8 \times 10^{10} = 7.38 \times 10^{11}$$



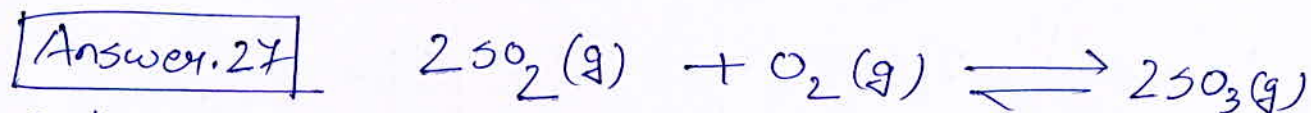
Initial moles,	2	2	0	0
Equilibrium,	$2-x$	$2-x$	x	x
Concentration,	$\frac{2-x}{V}$	$\frac{2-x}{V}$	$\frac{x}{V}$	$\frac{x}{V}$

Then $[A] = [B]$ Given, $\frac{x}{V} = \frac{3(2-x)}{V} \Rightarrow \boxed{x = 1.5}$

Then, $[A] = [B] = \frac{2-1.5}{V} = \frac{0.5}{V}$, $[C] = [D] = \frac{1.5}{V}$

$$K_c = \frac{\left(\frac{1.5}{V}\right)^2}{\left(\frac{0.5}{V}\right)^2} = \frac{1.5 \times 1.5}{0.5 \times 0.5} = 9$$

Answer. 26 Since $\Delta G^\circ < 0$, thus forward reaction is favoured, thus concentration of products is always greater than concentration of reactants. Therefore, equilibrium constant will be greater than unity



Initial moles,	5	5	0
At equilibrium,	$5-2x$	$5-x$	$2x$

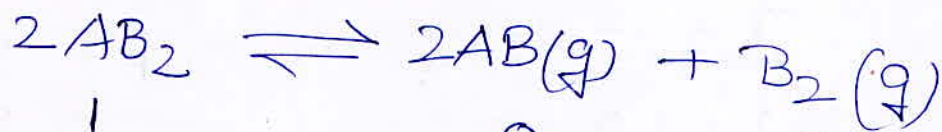
Given that, $2x = \frac{60}{100} \times 5 \Rightarrow \boxed{x = 1.5}$

So, $5-3 = 2$, $5-1.5 = 3.5$, $2 \times (1.5) = 3$

Total moles at equilibrium = $2 + 3.5 + 3 = 8.5$

$$p_{O_2} = \frac{3.5}{8.5} \times 1 = 0.41 \text{ atm}$$

Answer-35



Initial moles,

1

0

0

At equilibrium,

$1-\alpha$

α

$\frac{\alpha}{2}$

$$\text{Total moles at equilibrium} = 1 - \cancel{\alpha} + \cancel{\alpha} + \frac{\alpha}{2} \\ = 1 + \frac{\alpha}{2}$$

$$p_{AB_2} = \frac{1-\alpha}{1+\frac{\alpha}{2}} p, \quad p_{AB} = \frac{\alpha}{1+\frac{\alpha}{2}} p$$

$$p_{B_2} = \frac{\alpha/2}{1+\alpha/2} p$$

$$K_p = \frac{(p_{AB})^2 (p_{B_2})}{(p_{AB_2})^2} = \frac{\left(\frac{\alpha}{1+\frac{\alpha}{2}} p\right)^2 \left(\frac{\alpha/2}{1+\frac{\alpha}{2}} p\right)}{\left(\frac{1-\alpha}{1+\frac{\alpha}{2}} p\right)^2}$$

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

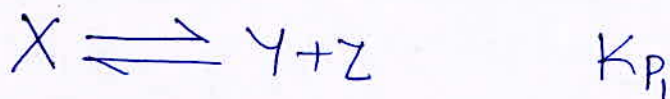
Since α is much less than 1, therefore α can be neglected with respect to 1 in denominator. Then,

$$K_p = \frac{\alpha^3 p}{2}$$

$$\Rightarrow \alpha^3 = \frac{2K_p}{p}$$

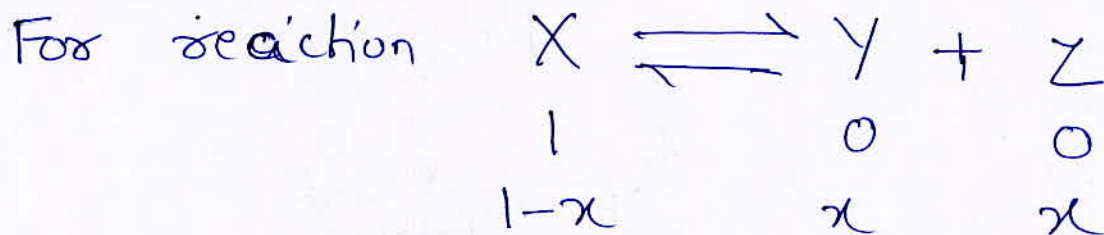
$$\Rightarrow \alpha = \left(\frac{2K_p}{p}\right)^{\frac{1}{3}}$$

Answer. 37

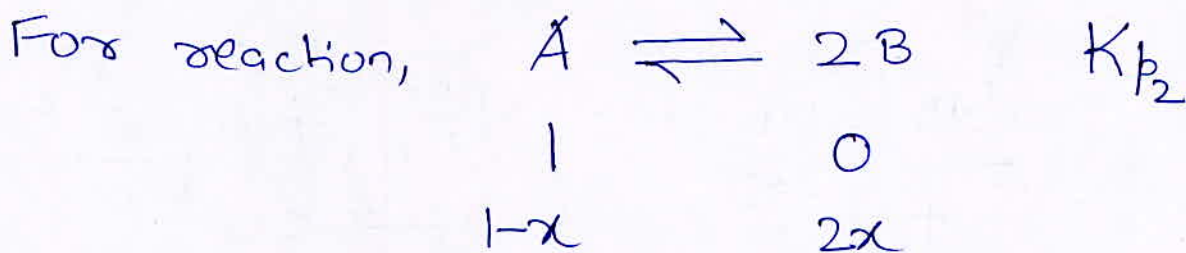


Given that,

$$\frac{K_{P_1}}{K_{P_2}} = \frac{9}{1} \rightarrow \textcircled{1}$$



$$K_{P_1} = \frac{x^2}{1-x^2} p_1 \rightarrow \textcircled{2}$$



$$K_{P_2} = \frac{4x^2}{1-x^2} p_2 \rightarrow \textcircled{3}$$

Dividing $\textcircled{2}$ by $\textcircled{3}$ and using $\textcircled{1}$, we get,

$$\frac{9}{1} = \frac{p_1}{4p_2}$$
$$\Rightarrow \frac{p_1}{p_2} = \frac{36}{1}$$

L

Answer. 41



Initial moles, 3 3 2
At equilibrium, $3-x$ $3+x$ $2+x$

Given that $3-x=1.5 \Rightarrow \boxed{x=1.5}$

$$\Rightarrow n_{\text{PCl}_3} = 3+1.5 = 4.5$$

Answer. 42



Initial concentration, c c 0

At equilibrium, $c(1-x)$ $c(1-x)$ $2cx$

Given, $\boxed{K_c = \frac{K_f}{K_b} = 1}$

$$\text{Thus, } K_c = \left(\frac{2cx}{c(1-x)} \right)^2 = 1$$

$$\Rightarrow \left(\frac{2x}{1-x} \right)^2 = 1$$

Taking square root on both sides, we get,

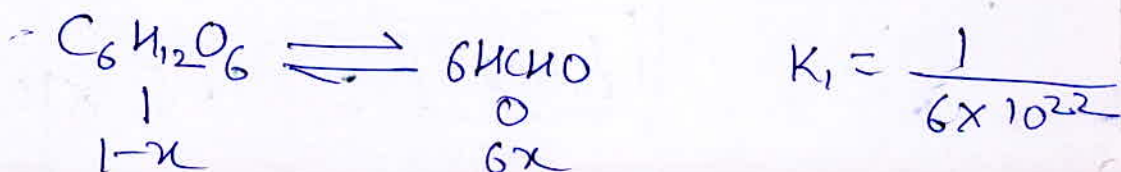
$$\frac{2x}{1-x} = 1 \Rightarrow x = \frac{1}{3} = 0.33$$

$$\text{or } \boxed{x = 33\%}$$

Answer. 43



then,



$$\text{So, } \frac{1}{6 \times 10^{-22}} = \frac{(6x)^6}{1-x}$$

Since equilibrium constant is very low, therefore degree of dissociation will be much less than 1, so $1-x \approx 1$. Then,

$$\frac{10^{-22}}{6} = 6^6 x^6$$

$$\Rightarrow x^6 = \frac{1}{6} \times \frac{10^{-22}}{6^6}$$

$$\Rightarrow x^6 = \frac{100}{6} \times \left(\frac{10^{-24}}{6^6} \right)$$

$$\Rightarrow (x^6)^{\frac{1}{6}} = \left(\frac{100}{6} \right)^{\frac{1}{6}} \left(\frac{10^{-24}}{6^6} \right)^{\frac{1}{6}}$$

$$\Rightarrow x = \frac{100}{6} (16.66)^{\frac{1}{6}} \times \frac{10^{-4}}{6}$$

~~Now,~~ $\Rightarrow x = 1.6 \times \frac{10^{-4}}{6}$

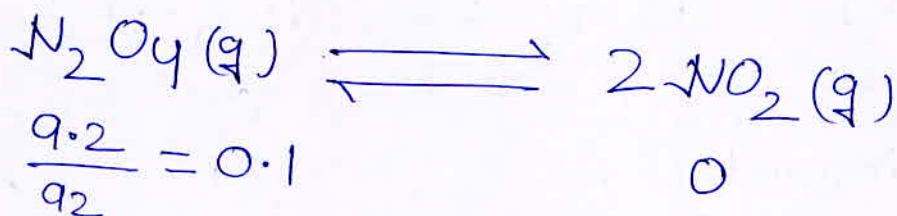
Now, concentration of HCHO at equilibrium is $6x$.

$$[\text{HCHO}] = 6 \times \left(1.6 \times \frac{10^{-4}}{6} \right)$$

$$\Rightarrow \boxed{[\text{HCHO}] = 1.6 \times 10^{-4}}$$

Answer. 44

Initial moles,



At equilibrium,

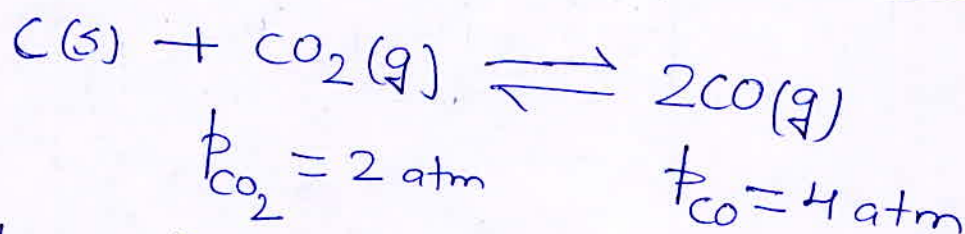


Given that, $\alpha = 0.5$, then,



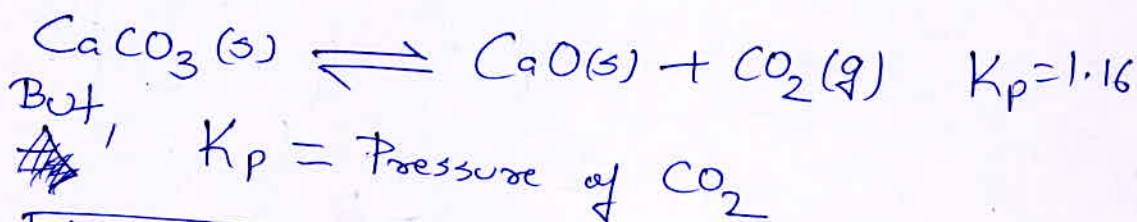
$$K_c = \frac{0.1^2}{0.05} = \frac{0.01}{0.05} = 0.2$$

Answer. 45



$$K_p = \frac{(p_{\text{CO}})^2}{(p_{\text{CO}_2})} = \frac{(4)^2}{2} = 8.$$

Answer. 48



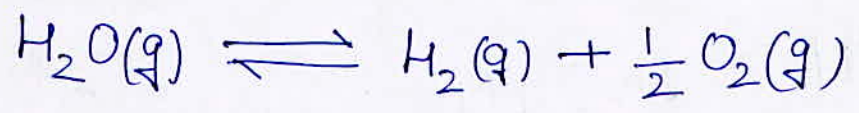
\Rightarrow $P_{\text{CO}_2} = 1.16$

Let x moles of CO_2 are formed. Then, by using $PV = nRT$, we get,

$$1.16 = \frac{x \times 0.0821 \times 10^3}{5}$$

\Rightarrow $x = 0.065$ or $x = 6.5\%$

Answer. 49



Initial moles,

$$1 \qquad 0 \qquad 0$$

At equilibrium,

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

Total moles at equilibrium = $1 - \cancel{\alpha} + \cancel{\alpha} + \frac{\alpha}{2} = 1 + \frac{\alpha}{2}$

$$p_{\text{H}_2\text{O}} = \frac{1-\alpha}{1+\frac{\alpha}{2}} p$$

$$p_{\text{H}_2} = \frac{\alpha}{1+\frac{\alpha}{2}} p$$

$$p_{\text{O}_2} = \frac{\alpha/2}{1+\frac{\alpha}{2}} p$$

$$K_p = \frac{\left(\frac{\alpha}{1+\frac{\alpha}{2}} p\right) \left(\frac{\alpha/2}{1+\frac{\alpha}{2}} p\right)^{\frac{1}{2}}}{\left(\frac{1-\alpha}{1+\frac{\alpha}{2}} p\right)}$$

$$\frac{1-\alpha}{1+\frac{\alpha}{2}} p$$

$$= \frac{\left(\frac{\cancel{2}\alpha}{\cancel{2}+\alpha} p\right) \left(\frac{\alpha}{\cancel{2}+\alpha} p\right)^{\frac{1}{2}}}{\frac{\cancel{2}(1-\alpha)}{\cancel{2}+\alpha} p}$$

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

Answer. 51



$K_p = 1.6 \text{ atm}$

Initial moles,	1	0	0
At equilibrium,	$1-x$	x	x
Given, $x = 0.5$,	$1-0.5$ $= 0.5$	0.5	0.5

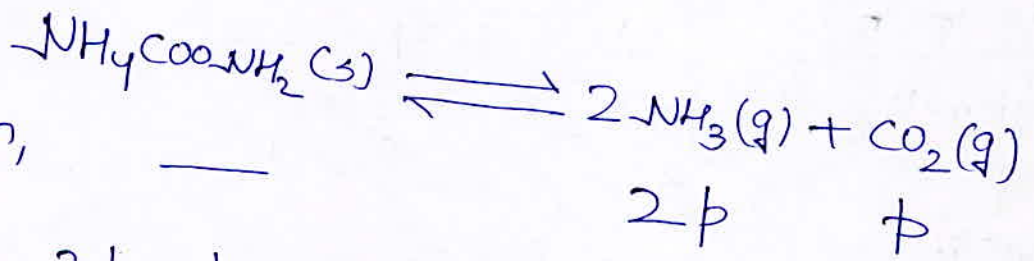
Total moles at equilibrium = 1.5

$$P_{\text{PCl}_5} = P_{\text{PCl}_3} = P_{\text{Cl}_2} = \frac{0.5}{1.5} p = \frac{1}{3} p$$

$$K_p = \frac{\left(\frac{1}{3} p\right)^2}{\left(\frac{1}{3} p\right)} = \frac{1}{3} p$$

$$\Rightarrow \boxed{p = 3 \times 1.6 = 4.8 \text{ atm}}$$

Answer. 53

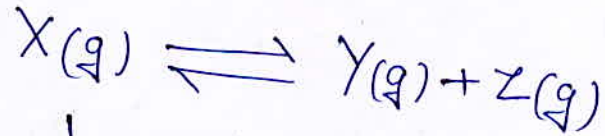


At equilibrium,

$$\text{Then, } 2p + p = 3 \text{ atm} \Rightarrow \boxed{p = 1 \text{ atm}}$$

$$\boxed{K_p = (2)^2 (1) = 4}$$

Answer. 55



$K_p = 1 \text{ atm}$

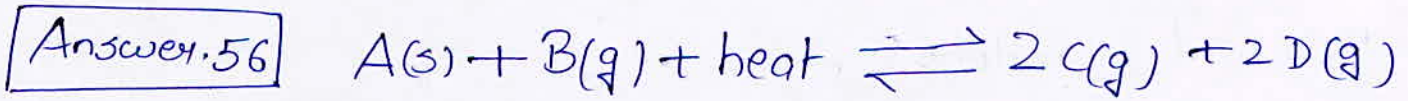
Initial moles,	1	0	0
At equilibrium,	$1-x$	x	x
$x = 0.5$, then,	$1-0.5$ $= 0.5$	0.5	0.5

Total moles at equilibrium = 1.5

$$P_x = P_y = P_z = \frac{0.5}{1.5} p = \frac{1}{3} p$$

$$K_p = \frac{\left(\frac{1}{3}P\right)^2}{\left(\frac{1}{3}P\right)} \Rightarrow \frac{1}{3}P = 1 \Rightarrow \boxed{P = 3 \text{ atm}}$$

$$\boxed{P_x = \frac{1}{3} \times 3 = 1 \text{ atm}}$$

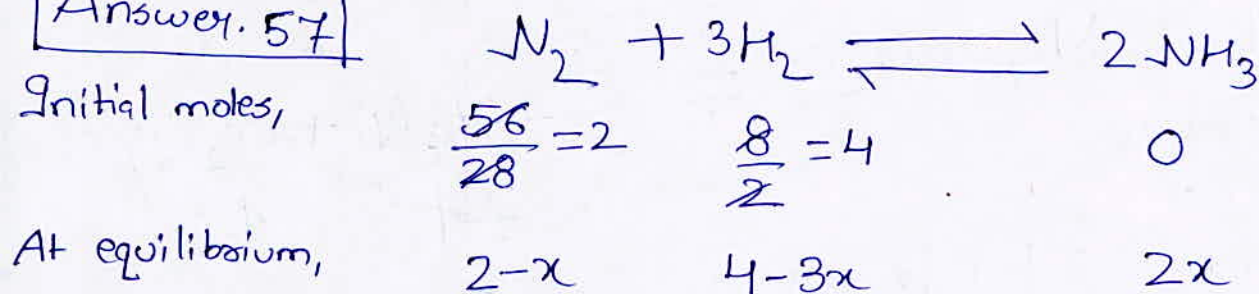


$$K = \frac{[C]^2 [D]^2}{[B]}$$

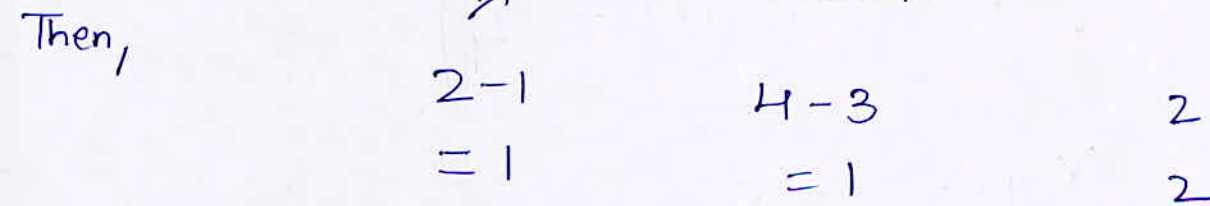
K will remain same, on re-establishment of ~~reaction~~ equilibrium. So,

$$\frac{[C]^2 [D]^2}{[B]} = \frac{[C]^2 [D]_{\text{new}}^2}{2[B]} \Rightarrow \boxed{[D]_{\text{new}} = \sqrt{2} [D]}$$

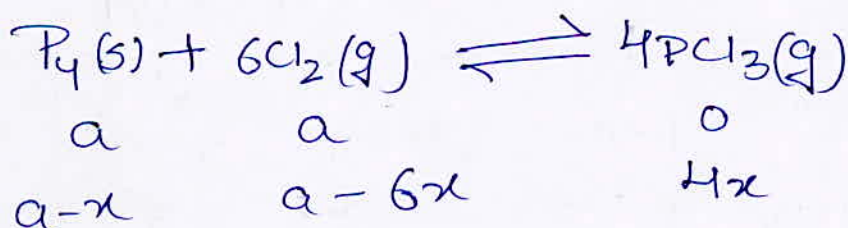
Answer. 57



Now, $2x = \frac{3 \times 4^2}{17} \Rightarrow \boxed{x = 1}$

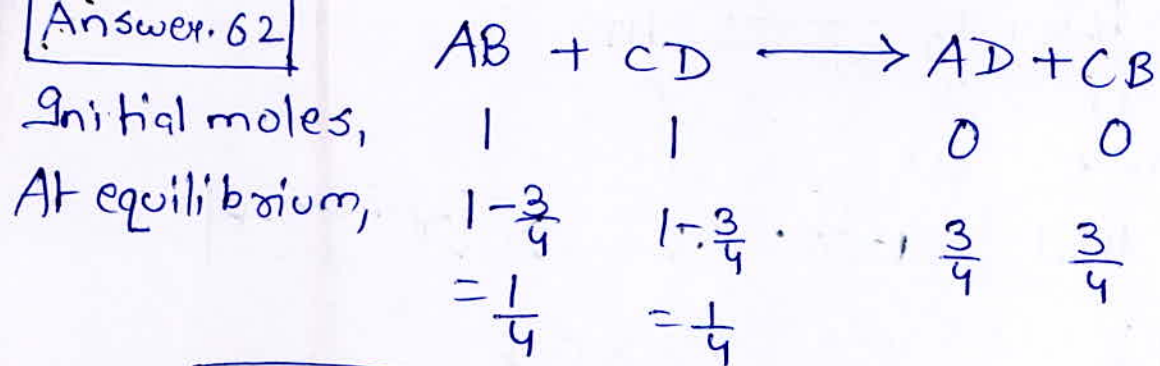


Answer. 59



So, we can see that at equilibrium $[P_4] > [Cl_2]$.

Answer. 62



$$K = \frac{\left(\frac{3}{4}\right)^2}{\left(\frac{1}{4}\right)^2} = 9$$

Answer. 66

Exothermic reactions means ΔH is (-)ve so, we can say that the backward reaction has higher activation energy than the forward reaction.

Answer. 68

Since for the given reaction ΔG is (-)ve, therefore increase in pressure will result in formation of more ~~reactants~~ products. It is a formation reaction therefore it is an exothermic reaction.

Answer. 78

There will be no effect of addition or removal of any solid species on the equilibrium. So, only change in temperature will change the partial pressure of O_2 .

Answer. 83



Since lime kiln is an open system ~~be~~ hence CO_2 formed escapes out. Due to continuous removal of one product, the reaction goes to completion.

Answer. 90



Initial moles,

1 2 0

At equilibrium,

$1-x$ $2-x$ $2x$

~~For 50% dissociation~~ Given

that,

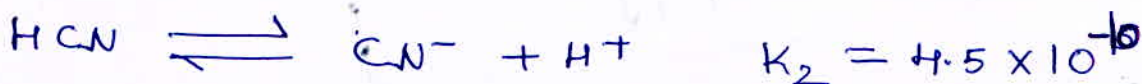
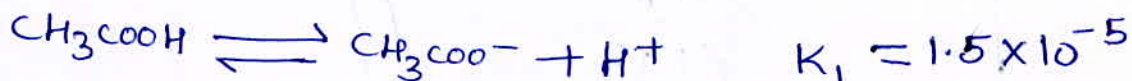
$$1-x = 0.2 \Rightarrow$$

$$\boxed{x = 0.8}$$

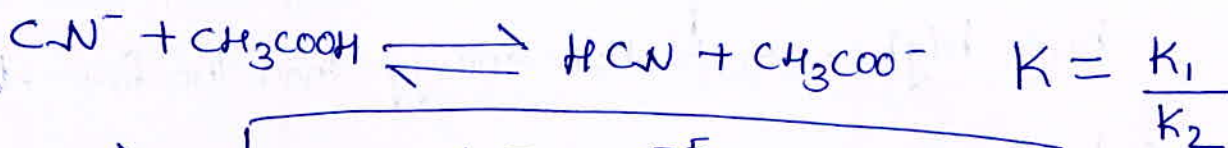
So,

$$\begin{array}{ccc} 0.2 & 2-0.8 & 2 \times 0.8 \\ & = 1.2 & = 1.6 \end{array}$$

Answer. 92



Reversing reaction (2) and then adding both the reactions, we get,



$$\Rightarrow \boxed{K = \frac{1.5 \times 10^{-5}}{4.5 \times 10^{-10}} = 3 \times 10^4}$$

Answer. 94



Initial moles,

$\frac{9.2}{92} = 0.1$ 0

At equilibrium,

$0.1-x$ $2x$

For 50% dissociation,

$0.1 - 0.05$
 $= 0.05$

~~2(0.05)~~
 $= 0.1$

$$\boxed{K = \frac{(0.1)^2}{0.05} = 0.2}$$

Answer. 95



Initial concn,

$3n$ n 0 0

At eqm,

$3n-x$ $n-x$ x x

Given that,

$$n-x = x \Rightarrow$$

$$\boxed{x = \frac{n}{2}}$$

$$\text{So, } \underline{\underline{[D] = x = \frac{n}{2}}}$$