# CHEMISTRY

## NCERT - FULL MARKS CHEMISTRY(TAMIL)

## PHYSICAL AND CHEMICAL EQUILIBRIUM

**Solved Problems**

**1.** One mole of $H_2$ and one mole of $I_2$ are allowed to attain equilibrium. If the equilibrium mixture contains $0.4$ mole of HI. Calculate the equilibrium constant.

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**2.** The equilibrium concentrations of $NH_3, N_2$ and $H_2$ are $1.8 \times 10^{-2}M, 1.2 \times 10^{-2}M$ and $3 \times 10^{-2}M$ are respectively.

Calculate the equilibrium constant for the formation of $NH_3$ from $N_2$ and $H_2$.

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**3.** The equilibrium constant at 298K for a reactions is 100.

$A + B \leftrightarrow C + D$

If the initial concentration of all the four species is 1 M, the equilibrium concentration of D (in mol $lit^{-1}$) will be

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**4.** For an equilibrium reaction $K_p = 0.0260$ at $25^\circ C \triangle H = 32.4 KJ \text{mol}^{-1}$, calculate $K_p$ at $37^\circ C$.

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Evaluate Yourself

**1.** Consider the following reaction

$Fe^{3+}(aq) + SCN^{-}(aq) \leftrightarrow [Fe(SCN)]^{2+}(aq)$

A solution is made with initial $Fe^{3+}, SCN^{-}$ concentration of $1 \times 10^{-3} M$ and $8 \times 10^{-4} M$ respectively. At equilibrium $[Fe(SCN)]^{2+}$ concentration is $2 \times 10^{-4} M$. Calculate the value of equilibrium constant.

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**2.** The atmospheric oxidation of NO

$2NO(g) + O_2(g) \leftrightarrow 2NO_2(g)$ was studied with initial pressure of 1 atm of NO and 1 atm of $O_2$. At equilibrium, partial pressure of oxygen is $0.52$ atm calculate $K_p$ of the reaction.

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**3.** The following water gas shift reaction is an important industrial process for the production of hydrogen gas.

$CO(g) + H_2O(g) \leftrightarrow CO_2(g) + H_2(g)$

At a given temperature $K_p = 2.7$. If $0.13$ mol of CO, $0.56$ mol of water, $0.78$ mol of $CO_2$ and $0.28$ mol of $H_2$ are introduced into a 2 L flask, and find out in which direction must the reaction proceed reach equilibrium.

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**4.** 1 mol of $PCl_5$, kept in a closed container of volume $1dm^3$ and was allowed to attain equilibrium at 423 K. Calculate the equilibrium composition of reaction mixture.

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**5.** The equilibrium constant for the following reaction is $0.15$ at 298K and 1 atm pressure.

$N_2O_4(g) \leftrightarrow 2NO_2(g)$,

$\triangle H_f^2 = 57.32 KJ \text{mol}^{-1}$

The reaction conditions are altered as follows.

(a) The reaction temperature is altered to $100^{\circ} C$ keeping the pressure at 1 atm, Calculate the equilibrium constant.

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## Evaluation Mcqs

**1.** If $K_b$ and $K_f$ for a reversible reactions are $0.8 \times 10^{-5}$ and $1.6 \times 10^{-4}$ respectively, the value of the equilibrium constant is,

A. $20$

B. $0.2 \times 10^{-1}$

C. $0.05$

D. none of these

**Answer: A**

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**2.** At a given temperature and pressure, the equilibrium constant values for the equilibria

$3A_2 + B_2 + 2C \overset{K_1}{\longleftrightarrow} 2A_3BC$ and

$A_3 + BC \overset{K_2}{\longleftrightarrow} \frac{3}{2}[A_2] + \frac{1}{2}B_2C$

The relation between $K_1$ and $K_2$ is

A. $K_1 = \frac{1}{\sqrt{K_2}}$

B. $K_2 = K_1^{-\frac{1}{2}}$

C. $K_1^2 = 2K_2$

D. $\frac{K_1}{2} = K_2$

**Answer: B**

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**3.** The equilibrium constant for a reaction at room temperature is K1 and that at 700 K is K2. If $K1 > K2$, then

A. The forward reaction is exothermic

B. The forward reaction is endothermic

C. The reaction does not attain equilibrium

D. The reverse reaction is exothermic

**Answer: A**

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**4.** The formation of ammonia from $N_2(g)$ and $H_2(g)$ is a reversible reaction

$N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g) + \text{Heat}$

What is the effect of increase of temperature on this equilibrium reaction

A. equilibrium is unaltered

B. formation of ammonia is favoured

C. equilibrium is shifted to the left

D. reaction rate does not change

**Answer: C**

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**5.** Solubility of carbon dioxide gas in cold water can increased by

A. increase in pressure

B. decrease in pressure

C. increase in volume

D. none of these

**Answer: A**

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**6.** Which one of the following in incorrect statement ?

A. for a system at equilibrium, Q is always less than the equilibrium constant

B. equilibrium can be attained from either side of the reaction

C. presence of catalyst affects both the forward reaction and reverse reaction to the same extent

D. Equilibrium constant varied with temperature

**Answer: A**

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**7.** $K_1$ and $K_2$ are the equilibrium constants for the reactions respectively.

$$N_2(g) + O_2(g) \overset{k_1}{\longleftrightarrow} 2NO(g)$$

$$2NO(g) + O_2(g) \overset{K_2}{\longleftrightarrow} 2NO_2(g)$$

What is the equilibrium constant for the reaction

$$NO_2(g) \leftrightarrow \frac{1}{2}N_2(g) + O_2(g)$$

A. $\frac{1}{\sqrt{K_1K_2}}$

B. $(K_1 = K_2)^{\frac{1}{2}}$

C. $\frac{1}{2K_1K_2}$

D. $\left(\frac{1}{K_1K_2}\right)^{\frac{3}{2}}$

**Answer: A**

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**8.** In the equilibrium, $2A(g) \leftrightarrow 2B(g) + C_2(g)$

the equilibrium concentrations of A, B and $C_2$ at 400 K are $1 \times 10^{-4}M, 2.0 \times 10^{-3}M, 1.5 \times 10^{-4}M$ respectively. The value of $K_C$ for the equilibrium at 400 K is

A. $0.06$

B. $0.09$

C. $0.62$

D. $3 \times 10^{-2}$

**Answer: A**

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**9.** An equilibrium constant of $3.2 \times 10^{-6}$ for a reaction means, the equilibrium is

A. largely towards forward direction

B. largely towards reverse direction

C. never established

D. none of these

**Answer: B**

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**10.** $\frac{K_C}{K_P}$ for the reaction, $N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g)$ is

A. $\frac{1}{RT}$

B. $\sqrt{RT}$

C. $RT$

D. $(RT)^2$

**Answer: D**

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**11.** For the raction $AB(g) \leftrightarrow A(g) + B(g)$, at equilibrium, AB is 20% dissociated at a total pressure of P, The equilibrium constant $K_p$ is related to the total pressure by the expression

A. $P = 24K_p$

B. $P = 8K_p$

C. $24P = K_p$

D. none of these

**Answer: A**

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**12.** In which of the following equilibrium, $K_p$ and $K_c$ are not equal?

A. $2NO(g) \leftrightarrow N_2(g) + O_2(g)$

B. $SO_2(g) + NO_2 \leftrightarrow SO_3(g) + NO(g)$

C. $H_2(g) + I_2(g) \leftrightarrow 2HI(g)$

D. $PCl_5(g) \leftrightarrow PCl_3(g) + Cl_2(g)$

**Answer: D**

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**13.** If x is the fraction of $PCl_5$ dissociated at equilibrium in the reaction

$PCl_5 \leftrightarrow PCl_3 + Cl_2$

then starting with $0.5$ mole of $PCl_5$, the total number of moles of reactants and products at equilibrium in

A. $0.5 - x$

B. $x + 0.5$

C. $2x + 0.5$

D. $x - 1$

**Answer: B**

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**14.** The values of $K_{P_1}$ and $K_{P_2}$ for the reactions

$X \leftrightarrow Y + Z$

$A \leftrightarrow 2B$ are in the ratio $9:1$ if degree of dissociation and initial concentration of X and A be equal then total pressure at equilibrium $P_1$ and $P_2$ are in the ratio

A. $36:1$

B. $1:1$

C. $3:1$

D. $1:9$

**Answer: A**

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**15.** In the reaction,

$Fe(OH)_3(s) \leftrightarrow Fe^{3+}(aq) + 3OH^-(aq)$,

if the concentration of $OH^-$ ions is decreased by 1/4 times, then the equilibrium concentration of $Fe^{3+}$ will

A. not changed

B. also decreased by 1/4 times

C. increase by 4 times

D. increase by 64 times

**Answer: D**

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**16.** Consider the reaction where $K_P = 0.5$ at a particular temperature

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

if the three gases are mixed in a container so that the partial pressure of each gas is initially I atm, then which one of the following is true

A. more $PCl_3$ will be produced

B. more $Cl_2$ will be produced

C. more $PCl_5$ will be produced

D. none of these

**Answer: C**

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**17.** Equimolar concentrations of $H_2$ and $I_2$ are heated to equilibrium in a 1 litre flask. What percentage of initial concentration of $H_2$ has reacted at equilibrium if rate constant for both horward and reverse reactions are equal

A. $33\ \%$

B. $66\ \%$

C. $35\ \%$

D. $16.5\ \%$

**Answer: A**

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**18.** In a chemical equilibrium, the rate constant for the forward reaction is $2.5 \times 10^2$ and the equilibrium constant is 50. The rate constant for the reverse reaction is,

A. $11.5$

B. $5$

C. $2 \times 10^{2}$

D. $2 \times 10^{-3}$

**Answer: B**

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**19.** Which of the following is not a general characteristic of equilibrium involving physical process

A. Equilibrium is possible only in a closed system at a given temperature

B. The opposing processes occur at the same rate and there is a dynamic but stable condition

C. All the physical processes stop at equilibrium

D. All measurable properties of the system remains constant

**Answer: C**

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**20.** For the formation of Two moles of $SO_3(g)$ from $SO_2$ and $O_2$, the equilibrium constant is $K_1$. The equilibrium constant for the dissociation of one mole of $SO_3$ into $SO_2$ and $O_2$ is

A. $1/K_1$

B. $K^2\_(1)$

C. $\left(\frac{1}{K_1}\right)^{1/2}$

D. (K_(1))/(2)`

**Answer: C**

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**21.** Match the equilibria with the corresponding conditions,

i) Liquid $\leftrightarrow$ Vapour

ii) Solid $\leftrightarrow$ Liquid

iii) Solid $\leftrightarrow$ Vapour

iv) solute (s) $\leftrightarrow$ Solute (Solution)

1) melting point

2) Saturated solution

3) Boiling point

4) Sublimation point

5) Unsaturated solution

| | (i) | (ii) | (iii) | (iv) |
|---|---|---|---|---|
| (a) | 1 | 2 | 3 | 4 |
| (b) | 3 | 1 | 4 | 2 |
| (c) | 2 | 1 | 3 | 4 |
| (d) | 3 | 2 | 4 | 5 |

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**22.** Consider the following reversible reaction at equilibrium, $A + B \leftrightarrow C$, If the concentration of the reactants A and B are doubled, then the equilibrium constant will

A. be doubled

B. become one fourth

C. be halved

D. remain the same

**Answer: D**

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**23.**

$\left[Co(H_2O)_6\right]^{2+}(aq)(\text{pink}) + 4Cl^-(aq) \leftrightarrow \left[CoCl_4\right]^{2-}(aq)(\text{blue}) + 6H_2O(l)$

In the above reaction at equilibrium, the reaction mixture is blue in colour at room temperature. On cooling this mixture, it becomes pink in

colour. On the basis of this information, which one of hte following is true?

A. $\triangle H > 0$ for the forward reaction

B. $\triangle H = 0$ for the reverse reaction

C. $\triangle H < 0$ for the forward reaction

D. Sign of the $\triangle H$ cannot be predicted based on this information.

**Answer: A**

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**24.** The equilibrium constants of the following reactions are :

$N_2 + 3H_2 \leftrightarrow 2NH_3 \quad , \quad K_1$

$N_2 + O_2 \leftrightarrow 2NO \quad , \quad K_2$

$H + \frac{1}{2}O_2 \leftrightarrow H_2O \quad , \quad K_3$

The equilibrium constant (K) for the reaction ,

$2NH_3 + \frac{5}{2}O_2 \overset{k}{\longleftrightarrow} 2NO + 3H_2O$, will be

A. $\frac{K_2^3 K_3}{K_1}$

B. $\frac{K_1 K_3^3}{K_2}$

C. $\frac{K_2 K_3^3}{K_1}$

D. $\frac{K_2 K_3}{K_1}$

**Answer: C**

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**25.** A 20 litre container at 400 K contains $CO_2(g)$ at pressure $0.4$ atm and an excess of SrO (neglect the volume of solid SrO). The volume of the container is now decreased by moving the movable piston fitted in the container. The maximum volume of the container, when pressure of $CO_2$ attains its maximum value will be :

Given that : $SrCO_2(S) \leftrightarrow SrO(S) + CO_2(g)$

$K_p = 1.6$ atm

A. 2 litre

B. 5 litre

C. 10 litre

D. 4 litre

**Answer: B**

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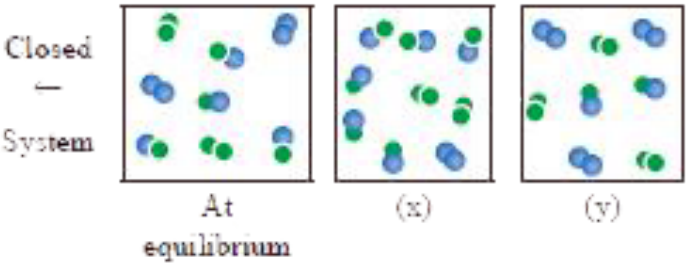
## Evaluation

**1.** For the reaction, $A_2(g) + B_2(g) \leftrightarrow 2AB(g) : \triangle H$ is -ve.

the following molecular scenes represent different reaction mixture (A-green, B-blue)




Calculate the equilibrium constant $K_P$ and $(K_C)$.

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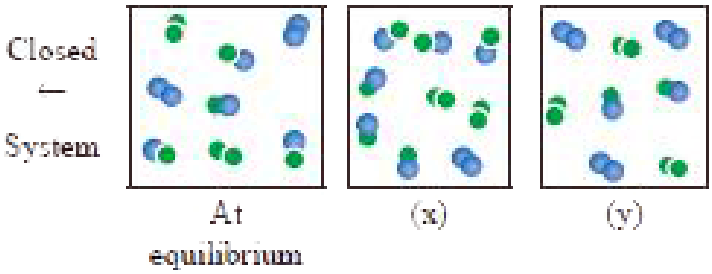
**2.** For the reaction, $A_2(g) + B_2(g) \leftrightarrow 2AB(g) : \triangle H$ is -ve.

the following molecular scenes represent different reaction mixture (A-green, B-blue)




For the reaction mixture represented by scene (x), (y) the reaction proceed in which directions?

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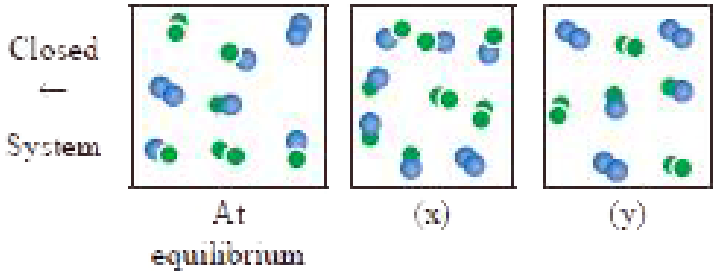
**3.** For the reaction, $A_2(g) + B_2(g) \leftrightarrow 2AB(g) : \triangle H$ is -ve.

the following molecular scenes represent different reaction mixture (A-green, B-blue)




What is the effect of increase in pressure for the mixture at equilibrium.

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**4.** Write a balanced chemical equation for a equilibrium reaction for which the equilibrium constant is given by expression

$$K_C = \frac{[NH_3]^4[O_2]^5}{[NO]^4[H_2O]^6}.$$

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**5.** One mole of $PCl_5$ is heated in one litre closed container. If $0.6$ mole of the chlorine is found at equilibrium, calculate the vlaue of equilibrium constant.

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**6.** For the reaction $SrCO_3(S) \leftrightarrow SrO(s) + CO_2(g)$

The value of equilibrium constant $K_p = 2.2 \times 10^{-4}$ at 1002 K. Calculate $K_C$ for the reaction.

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**7.** To study the decomposition of hydrogen iodide, a student fills an evacuated 3 litre flask with $0.3$ mol of HI gas and allows the reaction to proceed at $500^\circ C$. At equilibrium he found the concentration of HI which is equal to $0.05M$. Calculate $K_C$ and $K_P$.

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**8.** Oxidation of nitrogen monoxide was studied at $200^\circ C$ with initial pressures of 1 atm NO and 1 atm of $O_2$. At equilibrium partial pressure of oxygen is found to be $0.52$ atm calculate $K_P$ value.

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**9.** 1 mole of $CH_4$, 1 mole of $CS_2$ and 2 mol of $H_2S$ are 2 mol of $H_2$ are mixed in a 500 ml flask. The equilibrium constant for the reaction $K_C = 4 \times 10^{-2} \text{mol}^2 \text{lit}^{-2}$. In which direction will the reaction proceed to reach equilibrium?

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**10.** At particular temperature $K_C = 4 \times 10^{-2}$ for the reaction

$$H_2S(g) \leftrightarrow H_2(g) + \frac{1}{2}S_2(g)$$

Calculate $K_C$ for each of the following reaction

$$2H_2S(g) \leftrightarrow 2H_2(g) + S_2(g)$$

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**11.** At particular temperature $K_C = 4 \times 10^{-2}$ for the reaction

$$H_2S(g) \leftrightarrow H_2(g) + \frac{1}{2}S_2(g)$$

Calculate $K_C$ for each of the following reaction

$3H_2S(g) \leftrightarrow 3H_2(g) + \frac{3}{2}S_2(g)$

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**12.** 28g of Nitrogen and 6g of hydrogen were mixed in a 1 litre closed container. At equilibrium 17g $NH_3$ was produced. Calculate the weight of nitrogen, hydrogen at equilibrium.

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**13.** The equilibrium for the dissociation of $XY_2$ is given is,

$2XY_2(g) \leftrightarrow 2XY(g) + Y_2(g)$

If the degree of dissociation x is so small compared to one. Show that $2K_P = PX^3$ where P is the total pressure and $K_P$ is the dissociation equilibrium constant of $XY_2$.

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**14.** A sealed container was filled with 1 mol of $A_2(g)$, 1 mol $B_2(g)$ at 800 K and total pressure $1.00$ bar. Calculate the amounts of the components in the mixture at equilibrium given that K= 1 for the reaction $A_2(g) + B_2(g) \leftrightarrow 2AB(g)$.

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**15.** The equilibrium constant $K_P$ for the reaction $N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g)$ is $8.19 \times 10^2$ at 298K and $4.6 \times 10^{-1}$ at 498K. Calculate $\triangle H^0$ for the reaction.

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**16.** The partial pressure of carbon dioxide in the reaction $CaCO_3(s) \leftrightarrow CaO(s) + CO_2(g)$ is $1.017 \times 10^{-3}$ atm at $500^\circ C$. Calculate $K_P$ at $600^\circ C$ for the reaction. $\triangle H$ for the reaction is $181 KJ \text{mol}^{-1}$ and does not change in the given range of temperature.

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