



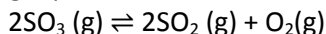
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CHEMICAL EQUILIBRIUM

Law of mass Action

1. One mole of SO_3 was placed in a vessel of 1 L capacity at a certain temperature constant K_c for the following equilibrium was established.



At equilibrium, 0.6 moles of SO_2 were formed. The equilibrium constant K_c for the reaction will be

- (A) 0.36 (B) 0.45 (C) 0.54 (D) 0.675

2. At 27°C K_p value for reaction $\text{CaCO}_3(\text{s}) + \text{CO}_2(\text{g})$ is 0.1 atm, calculate its K_c value.

- (A) 4×10^{-3} (B) 6×10^{-3} (C) 2×10^{-3} (D) 9×10^{-3}

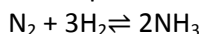
3. Solid NH_4I dissolves to the reaction at 400 K

$\text{NH}_4\text{I}(\text{s}) \rightleftharpoons \text{NH}_3(\text{g}) + \text{HI}(\text{g})$; $K_p = 16$ atm. In presence of catalyst, HI dissociates into H_2 and I_2 as $2\text{HI} \rightleftharpoons \text{H}_2 + \text{I}_2$. If partial pressure of H_2 at this temp is 1 atm in the container when both the equilibrium exist simultaneously, calculate K_p value of second equilibrium (for the dissociation of HI).

4. 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 addition of graphite. What is the value of K_p if the total pressure at equilibrium is 0.8 atm?

Exercise – 1

1. Write the expression for K_p and K_c for the following reactions

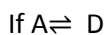


2. select the heterogeneous equilibrium from the following reaction

- (A) $\text{CaCO}_3(\text{s}) \rightleftharpoons \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$
(B) $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$

Exercise – 2

1. what is the value of equilibrium constant for the following reaction



$$K_1 = 2$$



$$K_2 = 5$$



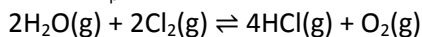
$$K_3 = 3$$

- (A) 60 (B) 40 (C) 20 (D) 30

2. In an equilibrium $\text{A} + \text{B} \rightleftharpoons \text{C} + \text{D}$; A and B are mixed in a vessel at temperature T. the initial concentration of A was twice the initial concentration of B. After the equilibrium has established, concentration of C was thrice the equilibrium concentration of B. Calculate K_c .

Units of Equilibrium Constant

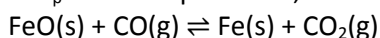
1. The value of K_p for the reaction



is 0.035 atm at 400°C , when the partial pressures are expressed in atmosphere.

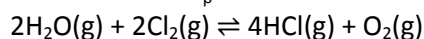
Calculate K_c for the reaction, $\frac{1}{2}\text{O}_2(\text{g}) + 2\text{HCl}(\text{g}) \rightleftharpoons \text{Cl}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$

2. K_p for the equilibrium,



At 1000°C is 0.4. if $\text{CO}(\text{g})$ at a pressure of 1 atm and excess $\text{FeO}(\text{s})$ are placed in a container at 1000°C , what are the pressure of $\text{CO}(\text{g})$ and $\text{CO}_2(\text{g})$ when equilibrium is attained?

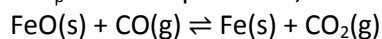
3. the value of K_p for the reaction



Is 0.035 atm at 400°C , when the partial pressures are expressed in atmosphere.

Calculate K_c for the reaction, $\frac{1}{2}\text{O}_2(\text{g}) \rightleftharpoons \text{Cl}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$

4. K_p for the equilibrium,



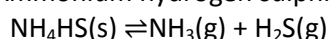
At 1000°C is 0.4. If $\text{CO}(\text{g})$ at a pressure of 1 atm and excess $\text{FeO}(\text{s})$ are placed in a container at 1000°C , what are the pressure of $\text{CO}(\text{g})$ and $\text{CO}_2(\text{g})$ when equilibrium is attained?

5. At 800 K a reaction mixture contained 0.5 mole of SO_2 , 0.12 mole of O_2 and 5 mole of SO_3 at equilibrium $2\text{SO}_2 + \text{O}_2 \rightleftharpoons 2\text{SO}_3$ is 833 lit/ mole. If the volume of the container is 1 litre, calculate how much O_2 is to be added at this equilibrium in order to get 5.2 moles of SO_3 at the same temperature.

(A) 2.34 moles (B) 0.34 moles (C) 1.43 moles (D) 3.23 moles

Exercise - 3

1. Ammonium hydrogen sulphite dissociates as follows



If solid NH_4HS is placed in an evacuated flask at certain temperature it will dissociate until the total pressure is 600 torr.

(A) calculate the value of equilibrium constant for the dissociation reaction

(B) Additional NH_3 is introduced into the equilibrium mixture without changing the temperature until partial pressure of NH_3 is 750 torr. What is the partial pressure of H_2S under these conditions? What is the total pressure in the flask?

2. At 700 K hydrogen and bromine react to form hydrogen bromide. The value of equilibrium constant for this reaction is 5×10^8 . Calculate the amount of H_2 , Br_2 and HBr at equilibrium, if a mixture of 0.6 mole of H_2 and 0.2 mole of Br_2 is heated to 700 K.

(A) 1.4, 1, 1.4 (B) 2.2, 0, 0.4 (C) 0.4, 0, 0.4 (D) 2.3, 1, 2.4

Reaction Quotient (Q)

1. For the reaction: $\text{A}_{(\text{aq})} + \text{B}_{(\text{aq})} \rightleftharpoons \text{C}_{(\text{aq})} + \text{D}_{(\text{aq})}$, the net rate of consumption of B at 25°C and at any time 't' is as given below

$$-\frac{d[\text{B}]}{dt} = \{4 \times 10^{-4} [\text{A}] [\text{B}] - 1.33 \times 10^{-5} [\text{C}] [\text{D}]\} \text{ mol L}^{-1} \text{ min}^{-1}$$

Predict whether the reaction will be spontaneous in the direction as written in reaction mixture in which each A, B, C and D is having a concentration of 1 mol L^{-1} ?

Le chatelier's Principle

1. $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$: $\Delta H = \text{negative}$

What are the conditions of temperature and pressure favourable for this reaction?

(A) Low temperature, low pressure

(B) high temperature, low pressure

(C) high temperature, high pressure

(D) low temperature, high pressure

2. under what conditions will the following reactions go in the forward direction?

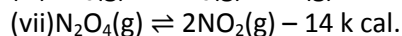
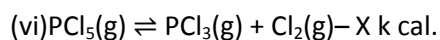
(i) $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g}) + 23 \text{ k cal.}$

(ii) $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g}) + 45 \text{ k cal.}$

(iii) $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}(\text{g}) - 43.2 \text{ k cal.}$

(iv) $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g}) + 27.8 \text{ k cal.}$

(v) $\text{C}(\text{s}) + \text{HO}_2(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + \text{H}_2(\text{g}) + X \text{ k cal.}$



3. the equilibrium constant K_p for the reaction

$\text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g)$ is $1.6 \times 10^{-4} \text{ atm}^{-2}$ at 400°C . what will be the equilibrium constant at 500°C if heat of the reaction in this temperature range is -25.14 k cal ?

(A) $1.231 \times 10^{-4} \text{ atm}^{-2}$

(B) $1.876 \times 10^{-7} \text{ atm}^{-2}$

(C) $1.462 \times 10^{-5} \text{ atm}^{-2}$

(D) $3.462 \times 10^{-5} \text{ atm}^{-2}$

Calculation of the Degree of Dissociation from Density Measurement

4. When PCl_5 is heated it dissociates into PCl_3 and Cl_2 . The density of the gas mixture at 200°C and at 250°C is 70.2 and 57.9 respectively. Find the degree of dissociation at 200°C and 250°C .

(A) 0.8

(B) 1.2

(C) 3.2

(D) 2.1

Exercise - 5

1. How much PCl_5 must be added to a one litre vessel at 250°C in order to obtain concentration of 0.1 mole of Cl_2 ? K_c for $\text{PCl}_5 \rightleftharpoons \text{PCl}_3 + \text{Cl}_2$ is 0.0414 mol/litre.

PROBLEMS

1. in an experiment 5 moles of HI were disclosed in a 5 liters container. At 717 K equilibrium constant for the gaseous reaction $2\text{HI}(g) \rightleftharpoons \text{H}_2(g) + \text{I}_2(g)$ is 0.025. Calculate the equilibrium concentrations of HI, H_2 and I_2 . What is the fraction of HI that decomposes?

2. Calculate the volume percent of chlorine at equilibrium in PCl_5 under a total pressure of 1.5 atm. ($K_p = 0.202 \text{ atm}$)

3. in a mixture of N_2 and H_2 initially in a mole ratio of 1 : 3 at 30 atm and 300°C , the equilibrium constant (K_p) of the mixture, for the reaction $\text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g)$

4. 256 g of HI was heated in a sealed bulb at 444°C till the equilibrium was attained. The acid was found to be 22% dissociated at equilibrium. Calculate equilibrium constants for synthesis and dissociation of HI?

5. Variation of equilibrium constant K with temperature T is given by Van't Hoff equation

$$\log K = \log A - \frac{\Delta H^0}{2.303 RT}$$

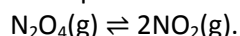
A graph between $\log K$ and T^{-1} was a straight line as shown and having $OP = 10$ and $\tan \theta = 0.5$.

Calculate

(i) equilibrium constant at 298 K, and

(ii) and equilibrium constant at 798 K, assuming ΔH^0 to be independent of temperature

6. The density of an equilibrium mixture of N_2O_4 and NO_2 at 1 atm. And 348 K is 1.84 gdm^{-3} . Calculate the equilibrium constant of the reaction



Objective

1. At a certain temperature 2 moles of carbonmonoxide and 3 moles of chlorine were allowed to reach equilibrium according to the reaction $\text{CO} + \text{Cl}_2 \rightleftharpoons \text{COCl}_2$ in a 5 lit vessel. At equilibrium if one mole of CO is present then equilibrium constant for the reaction is:

(A) 2

(B) 2.5

(C) 3.0

(D) 4

2. K_p for the reaction: $\text{CO}_2(\text{g}) + \text{H}_2(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g})$ is found to be 16 at a given temperature. Originally equal numbers of moles of H_2 and CO_2 were placed in the flask. At equilibrium, the pressure of H_2 is 1.20 atm. What is the partial pressure of CO and H_2O ?

- (A) 4.80 atm each (B) 9.60 atm each
(C) 2.40 atm each (D) 1.20 atm each

3. K_c for the reaction $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}(\text{g})$ is 4.0×10^{-6} at 400 K. K_p for the above reaction is

- (A) 2.4×10^{-3} (B) 4.0×10^{-6}
(C) $4.0 \times 10^{-6} \times (\text{RT})^2$ (D) none of these

4. K_c for the reaction

$\text{A}_{(\text{g})} + \text{B}_{(\text{g})} \rightleftharpoons \text{C}_{(\text{g})} + \text{D}_{(\text{g})}$, is 20 at 25°C if a container contains 1,2,4,5 moles per litre of $\text{A}_{(\text{g})}$, $\text{B}_{(\text{g})}$, $\text{C}_{(\text{g})}$

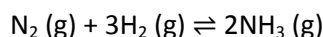
and $\text{D}_{(\text{g})}$ respectively at 25°C , then the reaction shall

- (A) proceed from left to right
(B) proceed from right to left
(C) be at equilibrium
(D) None of the above

5. When a sulphur in the form of S_8 is heated at 900 K, the initial pressure of one atm falls by 29% at equilibrium.

- (A) 1.16 atm^3 (B) 0.71 atm^3 (C) 2.55 atm^3 (D) 5.1 atm^3

6. for the reversible reaction



At 500°C , the rate of K_p is 1.44×10^{-5} when partial pressure is measured in atmosphere. The corresponding value of K_c with concentration in mol/L is

- (A) $\frac{1.44 \times 10^{-5}}{(0.082 \times 500)^{-2}}$ (B) $\frac{1.44 \times 10^{-5}}{(8.314 \times 773)^{-2}}$
(C) $\frac{1.44 \times 10^{-5}}{(0.082 \times 773)^2}$ (D) $\frac{1.44 \times 10^{-5}}{(0.082 \times 773)^{-2}}$

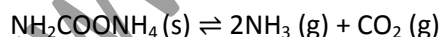
7. At temperature T , a compound $\text{AB}_2(\text{g})$ dissociates according to the reaction



With degree of dissociation x , which is small compared with unity. The expression for x in terms of the equilibrium constant K_p and total pressure P is

- (A) $x = \left(\frac{2K_p}{P}\right)^{1/3}$ (B) $x = \left(\frac{2P}{K_p}\right)^{1/3}$
(C) $x = \left(\frac{2K_p}{P}\right)^{1/2}$ (D) $\left(\frac{2K_p}{P}\right)$

8. Ammonium carbonate dissociates as

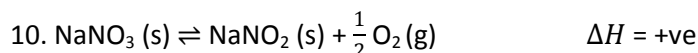


In a closed vessels containing ammonium carbonate ammonium carbonate in equilibrium, ammonia is added such that partial pressure of NH_3 now equals to original total pressure. Calculate the ratio of total pressure now the original pressure.

- (A) $\frac{35}{25}$ (B) $\frac{25}{35}$ (C) $\frac{31}{27}$ (D) $\frac{27}{30}$

9. The reaction: $3\text{O}_2 \rightleftharpoons 2\text{O}_3$, $\Delta H = +69,000$ calories is favoured by:

- (A) high temperature and low pressure
(B) high temperature and high pressure
(C) low temperature and high pressure
(D) low temperature and low pressure



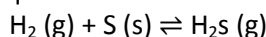
When NaNO_3 is heated in a closed vessel, oxygen is liberated and NaNO_2 is left behind. At equilibrium:

- (A) addition of NaNO_2 favors reverse reaction
- (B) addition of NaNO_3 favors forward reaction
- (C) increasing temperature favours forward reaction
- (D) decreasing pressure favours reverse reaction

11. The K_p of a reaction is 10 atm at 300K and 4 atm at 400K. the incorrect statement about the reaction is

- (A) the reaction is exothermic.
- (B) The E_a of forward reaction is more than that of backward reaction.
- (C) The rate of backward reaction increases more than that of forward reaction with increase of temperature.
- (D) The difference between heat of reaction at constant pressure and that at constant volume is RT .

12. The equilibrium constant for the reaction,



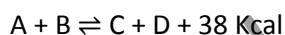
is 18.5 at 925 K and 9.25 at 1000 K respectively. Calculate the enthalpy of the reaction.

- (A) -10.20 kJ/mole
- (B) -7.18 kJ/mole
- (C) -2.15 kJ/mole
- (D) -4.30 kJ/mole

13. The enthalpies of two reaction are ΔH_1 and ΔH_2 (Both positive) with $\Delta H_2 > \Delta H_1$. If the temperature of reacting system is increased from T_1 to T_2 , predict which of the following alternatives is correct? (K_1, K_1' are eqbm. Constants for reaction 1 to T_1, T_2 and K_2, K_2' are eqbm. Constants for reaction 2 at T_1, T_2 .)

- (A) $\frac{K_1'}{K_1} = \frac{K_2'}{K_2}$
- (B) $\frac{K_1'}{K_1} > \frac{K_2'}{K_2}$
- (C) $\frac{K_1'}{K_1} > \frac{K_2'}{K_2}$
- (D) None of these

14. The equilibrium constant at 323°C is 1000. What would be its value in the presense of a catalyst for the forward reaction?



- (A) 1000 x concentration of catalyst
- (B) 1000
- (C) $\frac{1000}{\text{concentration of catalyst}}$
- (D) impossible to tell

15. A schematic plot of the K_{eq} vs inverse of temperature for a reaction is shown in the figure. The reaction must be

- (A) exothermic
- (B) endothermic
- (C) one with negligible enthalpy change
- (D) highly spontaneous at ordinary temperature

Assignments

Section – 1

Part – A(Level – I)

1. Why sealed soda water bottle on opening shows the evolution of gas with effervescence?
2. for a gas phase reaction for which $\Delta n_{gaseous} = 2$. Unit of K_p is

- High pressure is favourable for those reversible reactions in which there is in the number of molecules.
- Suggest four ways in which the concentration of hydrazine, N_2H_4 , could be increase in an $N_2(g) + 2H_2(g) \rightleftharpoons N_2H_4(g)$ $\Delta H = 95 \text{ kJ}$
- Explain why an equilibrium between $Br_2(l)$ $Br_2(g)$ would not be established if the bottle cap were removed from the bottle containing both these components.
- Higher the activation energy of a reaction, slower is the rate of reaction. [True/ false]
- Low pressure is favourable for melting of ice. [True/ False]
- The reactions having higher value of K_c are faster than the reactions having lower value of K_c , [True/ false]
- ice melts slowly at higher altitude, why?
- Under what vapour pressure of moisture in atmospheric conditions $CuSO_4 \cdot 5H_2O$ will be efflorescent if $CuSO_4 \cdot 5H_2O(s) + 2H_2O(g)$, $K_p = 62.73 \text{ mm}^2$ of Hg.

Level II

- The reaction $2SO_2 + O_2 \rightleftharpoons 2SO_3$ is made to take place at $t^\circ \text{C}$ in a closed vessel of 1 litre capacity and allowed to attain equilibrium. The equilibrium mixture contains 48 g SO_3 , 12.8 g SO_2 and 9.6 g of O_2 . Determine K_c .
- One mole of H_2 , 2 mol of I_2 and 3 mol of HI are injected in a 1 litre flask. What will be the concentration of H_2 , I_2 and HI at equilibrium? K_c for the equilibrium, $H_2(g) + I_2(g) \rightleftharpoons 2HI$ is 45.9.
- 15 g sample of BaO_2 is heated to 794°C in a closed evacuated vessel of 5 litres capacity. How many g of peroxide are converted to $BaO(s)$.
 $2BaO_2(s) \rightleftharpoons 2BaO(s) + O_2(g)$, $K_p = 0.5 \text{ atm}$.
- Consider the vapour phase dissociation of an oxoacid HXO_3 according to the equation:
 $4HXO_3(g) \rightleftharpoons 4XO_2(g) + 2H_2O(g) + O_2(g)$. Derive the expression: $K_p = \dots \dots \dots$,
Where P is the total pressure and P_{O_2} is partial pressure of O_2 .
- $PCl_5(g)$ at 500°K at an initial pressure of 600 mm Hg dissociates as: $PCl_5 \rightleftharpoons PCl_3 + Cl_2$ and the equilibrium pressure is 800 mm Hg at 500K. calculate K_p for the reaction assuming that no change in volume takes place.
- sulphide ions in alkaline solution react with solid sulphur to form polyvalent sulphide ions. The equilibrium constant for the formation of S_2^{2-} and S_3^{2-} from S and S^{2-} ions are 1.7 and 5.3 respectively. Calculate equilibrium constant K_c for the formation of S_3^{2-} from S_2^{2-} and S.
- The K_c for $A_2(g) + B_2(g) \rightleftharpoons 2AB(g)$ at 100°C is 0. If one litre flask containing one mole of A_2 is connected with a two litre flask containing 2 mole of B_2 , how many moles of AB will be formed at 100°C ?
- At 90°C the following equilibrium is established, $H_2(g) + S(s) \rightleftharpoons H_2S(g)$ $K = 6.8 \times 10^{-2}$ if 0.20 mole of hydrogen and 1.0 mol of sulphur are heated at 90°C in a 1.0 L vessel, what will be the partial pressure of H_2S at equilibrium?
- Solid ammonium carbonate decomposed according to the equation:
 $(NH_4)_2 CO_3(s) \rightleftharpoons 2NH_3(g) + CO_2(g) + H_2O(g)$
At a certain elevated temperature, the total pressure of the gases generated was 0.42 atm. At equilibrium. Calculate the equilibrium constant for the reaction.
- if a given quantity of phosphorus pentachloride is heated at 250°C and allowed to come to equilibrium at atmospheric pressure it is found to be dissociated to the extent of 80% into phosphorous trichloride and chlorine. If now, the pressure on this mixture is increased so that finally the equilibrium mixture occupies only one half of its original volume (temperature maintained constant).

- (i) what will be the % dissociation at the new pressure?
(ii) What will be the effect of adding He gas keeping the volume fixed at V/2.
11. For the equilibrium $\text{LiCl} \cdot 3\text{NH}_3(\text{s}) \rightleftharpoons \text{LiCl} \cdot \text{NH}_3(\text{s}) + 2\text{NH}_3$, $K_p = 9\text{atm}^2$ at 40°C . A 5 litre vessel contains 0.1 mole $\text{LiCl} \cdot \text{NH}_3$. how many moles of NH_3 would be added to the flask at the temperature to drive the backward reaction for nearly completion?
12. A sample of air consisting of N_2 and O_2 was heated to 2500 K until the equilibrium $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}(\text{g})$ was established with an equilibrium constant $K_c = 2.1 \times 10^{-3}$. At equilibrium, the mole % of NO was 1.8. Estimate the initial composition of air in mole fraction of N_2 and O_2 .
65. in reaction: $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$, what will be the value of K_c at 35°C if N_2O_4 is dissociated to the extent of 20% under a pressure of 1 atmosphere.
13. what is the vapour density of mixture of PCl_5 at 250°C when it has dissociated to the extent of 80%.
14. Two solids components A and B dissociate into gaseous products at 20°C as
(i) $\text{A}(\text{s}) \rightleftharpoons \text{A}'(\text{g}) + \text{H}_2\text{S}(\text{g})$
(ii) $\text{B}(\text{s}) \rightleftharpoons \text{B}'(\text{g}) + \text{H}_2\text{S}(\text{g})$
At 20°C , pressure over excess solid A is 50 mm Hg and that over excess solid B is 68 mm Hg. Find
(i) The dissociation constants of A and B
(ii) Ratio of number of moles of A' and B' in the vapour phase over a mixture of solids A and B
(iii) The total pressure of gas over the solid mixture.

Part – II
(Multiple Choice Question)
(single Option Correct)

1. For the reaction, $2\text{HI}(\text{g}) \rightleftharpoons \text{H}_2(\text{g}) + \text{I}_2(\text{g})$, which of the following facts hold good?
(a) $K_p = K_c$
(b) $K_p > K_c$
(c) $K_p < K_c$
(d) K_p and K_c can not be correlated unless pressure of the system is given.
2. For the reaction $\text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g}) \rightleftharpoons \text{PCl}_5(\text{g})$, the value of K_p at 250°C is 0.61atm^{-1} . The value of K_c at this temperature will be
(A) $15(\text{mol/l})^{-1}$ (B) $26.19(\text{mol/l})^{-1}$ (C) $35(\text{mol/l})^{-1}$ (D) $52(\text{mol/l})^{-1}$
3. for the reaction $2\text{NO}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_5(\text{g})$ if the equilibrium constant K_p , then the equilibrium constant for the reaction $2\text{N}_2\text{O}_5 \rightleftharpoons 4\text{NO}_2(\text{g}) + \text{O}_2(\text{g})$ would be
(A) K_p^2 (B) $2/K_p$ (C) $1/K_p^2$ (D) $1/\sqrt{K_p}$
4. For the reaction $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$, the equilibrium constant K_p changes with
(A) total pressure (B) catalyst
(C) the amount amounts of H_2 and I_2 present (D) temperature
5. The equilibrium constant for the reaction $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}(\text{g})$ is 4×10^{-4} at 200 K. in the presence of a catalyst the equilibrium is attained 10 times faster. Therefore the equilibrium constant in presence of the catalyst at 200 K is
(A) 4×10^{-3} (B) 4×10^{-4} (C) 4×10^{-5} (D) None
6. For the reaction $\text{Cu}(\text{s}) + 2\text{Ag}^+(\text{aq}) \rightleftharpoons \text{Cu}^{2+}(\text{aq}) + 2\text{Ag}(\text{s})$ the equilibrium constant, K_c is given by
(A) $\frac{[\text{Cu}^{2+}][\text{Ag}]^2}{[\text{Cu}][\text{Ag}^+]^2}$ (B) $\frac{[\text{Cu}][2\text{Ag}]}{[\text{Cu}^{2+}][2\text{Ag}^+]}$
(C) $\frac{[\text{Cu}^{2+}]}{[\text{Ag}^+]^2}$ (D) $\frac{[\text{Ag}^+]^2}{[\text{Cu}^{2+}]}$

7. In the gas phase reaction $C_2H_4 + H_2 \rightleftharpoons C_2H_6$, the equilibrium constant can be expressed in units
 (A) $l^{-1} \text{ mole}^{-1}$ (B) lit mole^{-1} (C) $\text{mole}^2 \text{ lit}^{-2}$ (D) mole lit^{-1}
8. for the reaction $C(s) + CO_2(g) \rightleftharpoons 2CO(g)$ the partial pressure of CO_2 and CO are 2.0 and 4.0 atm respectively at equilibrium. The K_p for the reaction is
 (A) 0.5 (B) 4.0 (C) 8.0 (D) 32.0
9. $CH_3COOH + C_2H_5OH = CH_3COOC_2H_5 + H_2O$. In this reaction one mole each of acetic acid and ethyl alcohol are heated in presence of little conc. H_2SO_4 . On equilibrium being attained the value of K_c is 4. What amount of ethyl acetate is formed?
 (A) 88 g (B) 176 g (C) 29.33 g (D) 58.67 g
10. For $N_2 + 3H_2 \rightleftharpoons 2NH_3 + \text{heat}$
 (A) $K_p = K_c$ (B) $K_p = K_c RT$ (C) $K_p = K_c (RT)^{-2}$ (D) $K_p = K_c (RT)^{-1}$
11. One mole of ethanol is treated with one mole of ethanoic acid at $25^\circ C$. One-fourth of the acid changes into ester at equilibrium. The equilibrium constant for the reaction will be
 (A) $1/9$ (B) $4/9$ (C) 9 (D) $9/4$
12. Given the following reaction at equilibrium: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
 Some inert gas is added at constant volume. Predict which of the following facts will be affected?
 (A) more of $NH_3(g)$ is produced
 (B) less of $NH_3(g)$ is produced
 (C) no effect on the degree of advancement of the reaction at equilibrium
 (D) K_p of the reaction is increased
13. For which reaction high pressure and high temperature is helpful in obtaining a high equilibrium yield;
 (A) $2NF \rightleftharpoons N_2(g) + 3F_2(g) - 54.40 \text{ kcal}$
 (B) $N_2(g) + 3H_2 \rightleftharpoons 2NH_3(g) + 22.08 \text{ kcal}$
 (C) $Cl_2(g) + 2O_2(g) \rightleftharpoons 2ClO_2(g) - 49.40 \text{ kcal}$
 (D) $2Cl_2O_7(g) \rightleftharpoons 2Cl_2(g) + 7O_2(g) + 126.8 \text{ kcal}$
14. for the gas phase reaction $C_2H_4(g) \rightleftharpoons C_2H_6(g)$; $\Delta H = -32.7 \text{ kcal}$ carried out in a vessel, the equilibrium concentration of C_2H_4 can be increased by
 (A) increasing temperature (B) decreasing temperature
 (C) removing some H_2 (D) All of the above
15. For the reaction: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$; $\Delta H = -ve$
 The formation NH_3 is favoured at
 (A) High pressure and low temperature
 (B) low pressure and high temperature
 (C) low pressure and low temperature
 (D) high pressure and high temperature
16. For the reaction $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$, the pressure of $CO_2(g)$ depends on
 (A) the mass of $CaCO_3(s)$
 (B) the mass of $CaO(s)$
 (C) the masses of both $CaCO_3(s)$ and $CaO(s)$
 (D) temperature of the system
17. for the decomposition reaction: $NH_2COONH_4(s) \rightleftharpoons 2NH_3(g) + CO_2(g)$
 The $K_p = 2.9 \times 10^{-5} \text{ atm}^3$. The total pressure of gases at equilibrium when 1 mole of $NH_2COONH_4(s)$ was taken to start with would be

- (A) 0.0194 atm (B) 0.0388 atm
(C) 0.0582 atm (D) 0.0766 atm

18. During thermal dissociation of a gas, the vapour density

- (A) remains the same
(B) increase
(C) decreases
(D) increase in some cases and decrease in other

19. The equilibrium constant for the reaction $\text{Br}_2 \rightleftharpoons 2\text{Br}$ at 500 K and 700 K are 1×10^{-10} and 1×10^{-5} respectively. The reaction is

- (A) endothermic (B) exothermic (C) fast (D) slow

20. The relationship between K_p and K_c is correctly shown as

- (A) $K_c = K_p(RT)^{\Delta n}$ (B) $K_p = K_c(RT)^{-\Delta n}$ (C) $K_p = K_c(RT)^{\Delta n}$
(D) $K_c = K_p(RT)^{-\Delta n}$

21. The equilibrium constant of the reaction $\text{SO}_2 + \frac{1}{2}\text{O}_2 \rightleftharpoons \text{SO}_3$ and $2\text{SO}_2 + \text{O}_2 \rightleftharpoons 2\text{SO}_3$ are K_1 and K_2 respectively. The relationship between K_1 and K_2 is

- (A) $K_1 = K_2$ (B) $K_2 = K_1^2$ (C) $K_1 = \sqrt{K_2}$ (D) $K_2 = \sqrt{K_1}$

22. Which of the following statement is/are correct for a reversible reaction?

- (A) Reaction quotient (Q) is the ratio of the product of arbitrary molar concentrations of the products to that of reactants
(B) Q may be $\leq K$
(C) At a given temperature both Q and K vary with reaction progress
(D) When $Q > K$, the reaction proceeds to backward direction before coming to stand still.

23. Which of the following will not affect the value of equilibrium constant of a reaction?

- (A) change in concentration of the reaction
(B) change in temperature
(C) change in pressure
(D) addition of catalyst

24. Which of the following statement(s) is (are) wrong?

- (A) at equilibrium concentration of reactant and product become constant because the reaction stops
(B) addition of catalyst speeds up the forward reaction more than the backward reaction
(C) equilibrium constant of an exothermic reaction decreases with increase of temperature
(D) K_p is always greater than K_c

25. for the following two reaction equilibrium constants are given

- (i) $\text{A (g)} + \text{B (g)} \rightleftharpoons \text{C (g)} + \text{D (g)}$ $K_1 = 1/3$
(ii) $\text{E (g)} + 2\text{B (g)} \rightleftharpoons \text{C (g)} + 4\text{D (g)}$ $K_2 = 6$

The equilibrium constant for the reaction

- (iii) $\text{A (g)} + 3\text{B (g)} + \text{E (g)} \rightleftharpoons 2\text{C (g)} + 5\text{D (g)}$

26. Compound X dissociates according to the reaction $2\text{X (g)} \rightleftharpoons 2\text{Y (g)} + \text{Z (g)}$ with degree of dissociation α which is small compared with unity, if expression for α in terms of equilibrium constant K_p and total pressure P is given as $\alpha = \left(\frac{2K_p}{P}\right)^{1/n}$. The value of n is

COMPREHENSION TYPE

Read the paragraph carefully and answer the following questions

Bodenstein carried out the determination of equilibrium constant of phosgene equilibrium by introduction CO and Cl₂ at known pressure in a reaction bulb and measuring the equilibrium pressure from the attached monometer. In one experiment, CO at 342 mm and Cl₂ at 351.4 mm were introduced. The equilibrium pressure was found to be 439.5 mm. At equilibrium if partial pressure of COCl₂ is 'x' mm at 127° C.

Reaction is: $\text{CO} + \text{Cl}_2 \rightleftharpoons \text{COCl}_2$

- (i) Value of x is
(A) 88.1 mm (B) 97.5 mm (C) 253.9 mm (D) 351.4 mm
- (ii) The K_p for the above reaction is;
(A) 0.029 atm⁻¹ (B) 760mm⁻¹ (C) 22.5 atm⁻¹ (D) 29.5 atm
- (iii) The volume of reacting vessel is decreased by 3 times, K_p changes by:
(A) 3 times increased (B) remains constant
(C) $\frac{1}{3}$ times decreased (D) $\frac{1}{9}$ times increased

MATCHING

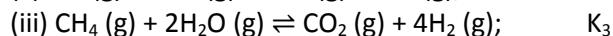
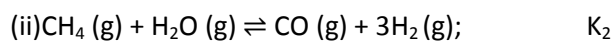
Match the following reaction in list – 1 with the factors in list – 2

List – 1	List – 2
(A) $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$ (Exothermic)	(p) Forward shift by rise in pressure
(B) $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$ (Exothermic)	(q) unaffected by change in pressure
(C) $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}(\text{g})$ (Endothermic)	(r) Forward shift by rise in temperature
(D) $\text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g}) \rightleftharpoons \text{PCl}_5(\text{g})$ (Endothermic)	(s) Forward shift by lowering the temperature
	(t) Backward shift by increasing the volume

Section - II

1. One mole of N₂O₄ (g) at 300 K is kept in a closed container under one atmosphere. It is heated to 600 K when 20% by mass of N₂O₄(g) decompose to NO₂(g). the resultant pressure is
(A) 1.2 atm (B) 2.4 atm (C) 2.0 atm (D) 1.0 atm
2. At constant temperature, the equilibrium constant (K_p) for the decomposition reaction $\text{N}_2\text{O}_4 \rightleftharpoons 2\text{NO}_2$ is expressed by $K_p = (4x^2 p)/(1-x^2)$, where P = pressure, the following statements is true?
(A) K_p increases with increase of P
(B) K_p increases with increases of x
(C) K_p increases with decreases of x
(D) K_p remains constant with change in P and x.
3. for which of the following reaction, $K_p = K_c$?
(A) $2\text{NOCl}(\text{g}) \rightleftharpoons 2\text{NO}(\text{g}) + \text{Cl}_2(\text{g})$
(B) $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$
(C) $\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightleftharpoons 2\text{HCl}(\text{g})$
(D) $\text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g}) \rightleftharpoons \text{PCl}_5(\text{g})$
4. The rate constant of a reaction depends on
(A) temperature (B) Mass
(C) density (D) time
5. for the chemical reaction $3\text{X}(\text{g}) + \text{Y}(\text{g}) \rightleftharpoons \text{X}_3\text{Y}(\text{g})$, the amount of X₃Y at equilibrium is affected by

- (A) Temperature and pressure
 (B) temperature only
 (C) Pressure only
 (D) temperature, pressure and catalyst
6. The rate at which a substance reacts depends on its
 (A) atomic mass (B) equivalent mass
 (C) molecular mass (D) active mass
7. For the equilibrium, $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$
 The forward reaction at constant temperature is favoured by
 1. introducing an inert gas at constant volume
 2. introducing chlorine gas at constant volume
 3. introducing an inert gas at constant pressure
 4. increasing the volume of the container
 5. introducing PCl_5 at constant volume
 (A) 1,2 (B) 4,5 (C) 2,3,4 (D) 3,4,5
8. The equilibrium $\text{SO}_2\text{Cl}_2(\text{g}) \rightleftharpoons \text{SO}_2(\text{g}) + \text{Cl}_2(\text{g})$ is attained at 25°C in a closed container and inert gas helium is introduced, which of the following statements (s) is/are correct?
 1. concentration of SO_2 , Cl_2 and SO_2Cl_2 change
 2. more chlorine is formed
 3. concentration of SO_2 is reduced
 4. More SO_2Cl_2 is formed
 (A) 1,2,3 (B) 2,3,4 (C) 3,4 (D) None
9. In what manner will increase of pressure affect the following equation?
 $\text{C}(\text{s}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + \text{H}_2(\text{g})$
 (A) shift in the forward direction
 (B) shift in the reverse direction
 (C) increase in the yield of hydrogen
 (D) No effect
10. the decomposition of phosgene
 $\text{COCl}_2(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + \text{Cl}_2(\text{g})$
 Is an endothermic process. Which of the following factors will cause the value of equilibrium constant to increase?
 (A) Adding Cl_2 (B) Adding $\text{He}(\text{g})$
 (C) increasing the temperature
 (D) Decreasing the total pressure
11. $\text{KNO}_3(\text{s})$ dissociates on heating as
 $\text{KNO}_3(\text{s}) \rightleftharpoons \text{KNO}_2(\text{s}) + \frac{1}{2}\text{O}_2(\text{g}) \quad \Delta H = -ve$
 At equilibrium in a closed container
 (A) addition of $\text{KNO}_3(\text{s})$ favours forward reaction
 (B) addition of $\text{KNO}_2(\text{s})$ favours reverse reaction
 (C) increasing temperature favours forward reaction
 (D) decreasing pressure favours reverse reaction
12. for the following three reaction (i), (ii) and (iii), equilibrium constants are given:
 (i) $\text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + \text{H}_2(\text{g}); \quad K_1$



Which of the following relation is correct?

- (A) $K_3 K_2^3 = K_1^2$ (B) $K_1 \sqrt{K_2} = K_3$ (C) $K_2 K_3 = K_1$ (D) $K_3 = K_1 K_2$

13. for the reaction



Which one is correct representation?

- (A) $K_p = \dots\dots$ (B) $\dots\dots\dots$ (C) $K_p = K_c (RT)^2$ (D) All of these

14. the molecular weight of PCl_5 is 208.32 but when heated to 230°C , it is reduced to 124. The extent of dissociation of PCl_5 at this temperature will be

- (A) 6.8% (B) 68% (C) 46% (D) 64%

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