THE GURUKUL INSTITUTE

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CHEMICAL EQUILIBRIUM

Law of mass Aciton

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.

$2SO_3\ (g) \rightleftharpoons 2SO_2\ (g) + O_2(g)$

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 $CaCO_3\ (s) + CO_2\ (g)$ 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

$NH_4(s) \rightleftharpoons NH_3(g) + HI(g)$; K_p = 16 atm. In presence of catalyst, HI dissociates into H_2 and I_2 as $2HI \rightleftharpoons H_2 + I_2$. 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 Kp 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

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

2. select the heterogeneous equilibrium from the following reaction

(A) $CaCO_3\ (s) \rightleftharpoons CaO(s) + CO_2\ (g)$

(B) $H_2(g) + I_2(g) \rightleftharpoons 2HI\ (g)$

Exercise – 2

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

If $A \rightleftharpoons D$

$A \rightleftharpoons B$ $K_1 = 2$

$B \rightleftharpoons C$ $K_2 = 5$

$C \rightleftharpoons D$ $K_3 = 3$

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

2. In an equilibrium $A + B \rightleftharpoons C + D$; 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

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

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

Calculate K_c for the reaction, $\frac{1}{2}O_2(g) + 2HCl(g) \rightleftharpoons Cl_2(g) + H_2O(g)$

2. K_p for the equilibrium,

$FeO(s) + CO(g) \rightleftharpoons Fe(s) + CO_2(g)$

At 1000° C is 0.4. if CO(g) at a pressure of 1 atm and excess FeO(s) are placed in a container at 1000° C, what are the pressure of CO(g) and $CO_2(g)$ when equilibrium is attained?

3. the value of K_p for the reaction

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

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

Calculate K_c for the reaction, $\frac{1}{2}O_2(g) \rightleftharpoons Cl_2(g) + H_2O(g)$

4. K_p for the equilibrium,

$FeO(s) + CO(g) \rightleftharpoons Fe(s) + CO_2(g)$

At 1000° C is 0.4. If CO(g) at a pressure of 1 atm and excess FeO(s) are placed in a container at 1000° C, what are the pressure of CO(g) and CO_2 (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 $2SO_2 + O_2 \rightleftharpoons 2SO_3$ 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

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

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 temperature 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, 04 (D) 2.3, 1, 2.4

Reaction Quotient (Q)

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

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

Le chatelier's Principle

1. $N_2 + 3H_2 \rightleftharpoons 2NH_3$: ΔH = negative

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

(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) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ + 23 k cal.

(ii) $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ + 45 k cal.

(iii) $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ – 43.2 k cal.

(iv) $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$ + 27.8 k cal.

(v) $C(s) + HO_2(g) \rightleftharpoons CO_2(g) + H_2(g)$ + X k cal.

(vi)$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$– X k cal.
(vii)$N_2O_4(g) \rightleftharpoons 2NO_2(g)$ – 14 k cal.

3. the equilibrium constant K_p for the reaction
$N_2(g) + 3H_2(g)$ ………. $2NH_3(g)$ us 1.6×10^{-4} atm^{-2} at 400^o C. what will be the equilibrium constant at 500^o C if heat of the reaction in this temperature range is -25.14 k cal?

(A) $1.231 \times 10^{-4} atm^{-2}$
(B) $1.876 \times 10^{-7} atm^{-2}$
(C) $1.462 \times 10^{-5} atm^{-2}$
(D) $3.462 \times 10^{-5} atm^{-2}$

Calculation of the Degree of Dissociation form Density Measurement

4. When PCl_5 is heated it dissociates into PCl_2 and Cl_2. The density of the gas mixture at 200^o C and at 250^o C is 70.2 and 57.9 respectively. Find the degree of dissociation at 200^o C and 250^o 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^o C in order to obtain concentration of 0.1 mole of Cl_2? K_c for $PCl_5 \rightleftharpoons PCl_3 + Cl_2$ is 0.0414 mol/litre.

PLOBLEMS

1. in an experiment 5 moles of HI were disclosed in a 5 liters container. At 717 K equilibrium constant for the gaseous reaction 2HL (g) $\rightleftharpoons$ H_2 (g) + 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 atm)
3. in a mixture of N_2 and H_2 initially in a mole ratio of 1 : 3 at 30 atm and 300^o C, the equilibrium constant (K_p) of the mixture, for the reaction
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
4. 256 g of HI was heated in a sealed bulb at 444^o 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_4amd NO_2 at 1 atm. And 348 K is 1.84 gdm^{-3}. Calculate the equilibrium constant of the reaction
$N_2O_4(g) \rightleftharpoons 2NO_2(g)$.

Objective

1. At a certain temperature 2 moles of carbonmonoxide and 3 moles of chlorine were allowed to reach equilibrium according to the reaction $CO + Cl_2 \rightleftharpoons COCl_2$ 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: $CO_2(g) + H_2(g) \rightleftharpoons CO(g) + H_2O_{(g)}$ 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 $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ is 4.0×10^{-6} at 400 K. K_p for the above reaction is

(A) 2.4×10^{-3}
(B) $4.\ 0 \times 10^{-6}$
(C) $4.0 \times 10^{-6} \times (RT)^2$
(D) none of these

4. $K_c$for the reaction

$A_{(g)} + B_{(g)} \rightleftharpoons C_{(g)} + D_{(g)}$, is 20 at 25° C if a container contains 1,2,4,5 moles per litre of $A_{(g)}$, $B_{(g)}$, $C_{(g)}$ And $D_{(g)}$ respectively at 25° C, then the reaction shall

(A) proceed form 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_8osjeated 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

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

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

7. At temperature T, a compound $AB_2(g)$ dissociates according to the reaction

$2AB_2\ (g) \rightleftharpoons 2AB\ (g) + B_2\ (g)$

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

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

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: $3O_2 \rightleftharpoons 2O_3$, ΔH = + 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

10. $NaNO_3$ (s) ⇌ $NaNO_2$ (s) + $\frac{1}{2}$ O_2 (g) ΔH = +ve

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,

H_2 (g) + S (s) ⇌ H_2s (g)

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) -4.30kJ/mole

13. The enthalpies of two reaction are ΔH_1 and ΔH_2 (Both positive) with ΔH_2 >ΔH_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^o C is 1000. What would be its value in the presense of a catalyst for the forward reaction?

A + B ⇌ C + D + 38 Kcal

(A) 1000 x concentration of catalyst (B) 1000
(C) $\frac{1000}{conc\ entration\ \ of\ catalyst}$ (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 ……………………….

3. High pressure is favourable for those revesible reactions in which there is ………. in the number of molecules.
4. 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_2 (g) ΔH = 95 kJ
5. Explain why an equilibrium between $Br_2(\ell)$ $Br_2(g)$ would not be established if the bottle cap were removed from the bottle containing both these components.

6. Higher the activation energy of a reaction, slower is the rate of reaction. [True/ false]
7. Low pressure is favourable for melting of ice. [True/ False]
8. The reactions having higher value of K_c are faster than the reactions having lower value of K_c, [True/ false]
9. ice melts slowly at higher altitude, why?
10. Under what vapour pressure of moisture in atomospheric conditions $CuSO_4$, $5H_2O$ will be efflorescent if $CuSO_4 . 5H_2O(s) + 2H_2O(g)$, K_p = 62.73 mm^2 of Hg.

Level II

1. The reaction 2SO2 + O2$\rightleftharpoons$ 2SO3 is made to take place at t° 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.
2. 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.
3. 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 atm.

4. 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 =… … … … … … … … … … …,
Where P is the total pressure and Po_2 is partial pressure of O_2.
5. $PCl_5(g)$ 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. calculateK_p for the reaction assuming that no change in volume takes place.
6. 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 Kc for the formation of S_3^{-2} from S_2^{2-} and S.

7. The Kc 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?
8. At 90° C the following equilibrium is established, $H_2(g) + S(s) \rightleftharpoons H_2S(g)$ K = 6.8 x 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?
9. 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.

10. 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 phosphouroustri chloride 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 costant).

(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 $LiCl.3NH_3$ (s) ⇌ $LiCl.NH_3$ (s) + $2NH_3$,K_p = 9atm^2 at 40^o C. A 5 litre vessel contains 0.1 mole $LiCl.NH_3$ .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
N_2(g) + O_2(g) ⇌2NO(g)
Was established with an equilibrium constant Kc = 2.1 x 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: N_2O_4(g) ⇌ $2NO_2$(g), what will be the value of K_c at 35^o C if N_2O_4 is dissociated to the extent of 20% under a pressure of 1 atomosphere.

13. what is the vapour density of mixture of PCl_5 at 250^o C when it has dissociated to the ectent of 80%.
14. Two solids components A and B dissociate into gaseous products at 20^o C as
(i) A (s) ⇌ A ′(g) + H_2S (g)
(ii) B (s) ⇌ B ‘(g) + H_2S (g)
At 20^o 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, 2HI(g) ⇌H_2(g) + I_2(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 PCl_3 (g) + Cl_2(g) ⇌ PCl_5(g), the value of K_p at 250^o C is 0.61 atm^{-1}. The value of K_c at this temperature will be
(A) 15 (mol/l)$^{-1}$ (B) 26.19 (mol/l)$^{-1}$ (C) 35 (mol/l)$^{-1}$ (D) 52 (mol/l)$^{-1}$
3. for the reaction
$2NO_2(g) + \frac{1}{2} O_2(g) \rightleftharpoons N_2O_5(g)$ if the equilibrium constant Kp, then the equilibrium constant for the reaction $2N_2O_5$ ⇌$4NO_2$(g) + O_2(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 H_2(g) + I_2(g) ⇌ 2HI(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
N_2(g) + O_2(g) ⇌ 2NO(g) is 4x 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 x 10^{-3} (B) 4x 10^{-4} (C) 4 x 10^{-5} (D) None
6. For the reaction Cu(s) + $2Ag^+$ (aq) ⇌ Cu^{2+} (aq) + 2 Ag(s) the equilibrium constant, K_c is given by
(A) $\frac{[Cu^{2+}][Ag]^2}{[Cu][Ag^+]^2}$ (B) $\frac{[Cu][2Ag]}{[Cu^{2+}][2Ag^+]}$
(C) $\frac{[Cu^{2+}]}{[Ag^+]^2}$ (D) $\frac{[Ag^+]^2}{[Cu^{2+}]}$

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} $mole^{-1}$ (B) lit $mole^{-1}$ (C) $mole^2$ 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 valu 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 $N_2 + 3H_2 \rightleftharpoons 2NH_3$ + heat

(A) $K_p = K_c$ (B) $K_p = K_cRT$ (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° 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) noaffect 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 kcal

(B) $N_2(g) + 3H_2 \rightleftharpoons 2NH_3(g)$ + 22.08 kcal

(C) $Cl_2(g) + 2O_2(g) \rightleftharpoons 2ClO_2(g)$ – 49.40 kcal

(D) $2Cl_2O_7(g) \rightleftharpoons 2Cl_2(g) + 7O_2(g)$ + 126.8 kcal

14. for the gas phase reaction $C_2H_4(g) \rightleftharpoons C_2H_6(g)$; ΔH = -32.7 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: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$; ΔH = -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 $K_p = 2.9 \times 10^{-5}$ 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 $Br_2 \rightleftharpoons 2Br$ at 500 K abd 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 $SO_2 + \frac{1}{2} O_2 \rightleftharpoons SO_3$ and $2SO_2 + O_2 \rightleftharpoons 2SO_3$ 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 that 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) A (g) + B (g) $\rightleftharpoons$ C (g) + D (g) $K_1 = 1/3$
(ii) E (g) + 2B (g) $\rightleftharpoons$ C (g) + 4D (g) $K_2 = 6$
The equilibrium constant for the reaction
(iii) A (g) + 3B (g) + E (g) $\rightleftharpoons$ 2C (g) + 5D (g)

26. Compound X dissociates according to the reaction 2X (g) $\rightleftharpoons$ 2Y (g) + 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 Cl_2 at known pressure in a reaction bulb and measuring the equilibrium pressure from the attached monometer. In one experiment, CO at 342 nm and Cl_2 at 351.4 nm were introduced. The equilibrium pressure was found to be 439.5 nm. At equilibrium if partial pressure of $COCL_2$ B 'x' mm at 127° C.

Reaction is: $Cl + Cl_2 \rightleftharpoons COCl_2$

(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) N_2 (g) + $3H_2$ (g) $\rightleftharpoons$ $2NH_3$ (g) (Exothermic)	(p) Forward shift by rise in pressure
(B) $2SO_2$ (g) + O_2 (g) $\rightleftharpoons$ $2SO_3$(g) (Exothermic)	(q) unaffected by change in pressure
(C) N_2 (g) + O_2 (g) $\rightleftharpoons$ 2NO (g) (Endothermic)	(r) Forward shift by rise in temperature
(D) PCl_3 (g) + Cl_2 (g) $\rightleftharpoons$ PCl_5 (g) (Endothermic)	(s) Forward shift by lowering the temperature
	(t) Backward shift by increasing the volume

Section - II

1. One mole of N_2O_4 (g) at 300 K is kept in a closed container under one atmosphere. It is heated to 600 K when 20% by mass of N_2O_4(g) decompose to NO_2(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 $N_2O_4 \rightleftharpoons 2NO_2$ is expressed by

K_p= (4 x^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) 2NOCl(g) $\rightleftharpoons$ 2NO(g) + CL_2(g)

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

(C) H_2(g) + Cl_2(g) $\rightleftharpoons$ 2HCl(g)

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

4. The rate constant of a reaction depends on

(A) temperature (B) Mass

(C) density (D) time

5. for the chemical reaction

3X(g) + Y (g) $\rightleftharpoons$ X_3Y (g), the amount of X_3Y 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, PCl_5 (g) ⇌PCl_3(g) + Cl_2(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 SO_2Cl_2(g) ⇌ SO_2(g) + Cl_2(g) is attained at 25^{o} 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?
C(s) + H_2O(g) ⇌ CO(g) + H_2(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
$COCl_2$ (g) ⇌CO(g) + Cl_2 (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 He(g)
(C) increasing the temperature
(D) Decreasing the total pressure

11. KNO_3(s) dissociates on heating as
KNO_3 (s) ⇌ KNO_2 (s) + $\frac{1}{2}$ O_2 (g) ΔH = -ve
At equilibrium in a closed container
(A) addition of KNO_3(s) favoursfarward reaction
(B) addition of KNO_2(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) CO(g) + H_2O (g) ⇌ CO_2 (g) + H_2 (g); K_1

(ii)CH_4 (g) + H_2O (g) ⇌ CO (g) + $3H_2$ (g); K_2

(iii) CH_4 (g) + $2H_2O$ (g) ⇌ CO_2 (g) + $4H_2$ (g); K_3

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) $K_2K_3 = K_1$ (D) $K_3 = K_1K_2$

13. for the reaction

$CuSO_4$ x $5H_2O$ (s) ⇌ $CuSO_4$ x $3H_2O$(s) + $2H_2O$ (g)

Which one is correct representation?

(A) K_p = ……. (B) ……………… (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 230^0 C, it is reduced to 124. The ectent of dissociation of PCl_5 at this temperature will be

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