विध्न विचारत भीरु जन, नहीं आरम्भे काम, विपति देख छोड़े तुरंत मध्यम मन कर श्याम।
पुरुष सिंह संकल्प कर, सहते विपति अनेक, 'बना' न छोड़े ध्येय को, रघुबर राखे टेक।।

रचितः मानव धर्म प्रणेता
सद्गुरु श्री रणछोड़दासजी महाराज

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SPARKLES

Q.1 NO_2 is involved in the formation of smog and acid rain. A reaction that is important in the formation of NO_2 is $O_3(g) + NO(g) \rightleftharpoons O_2(g) + NO_2(g)$ $K_c = 6 \times 10^{34}$, if the air over Bansal Classes contained 1×10^{-6}M O_3, 1×10^{-5} M NO, 2.5×10^{-4} M NO_2 and 8.2×10^{-3} M O_2, what can we conclude?
(A) There will be a tendency to form more NO and O_3
(B) There will be a tendency to form more NO_2 and O_2
(C) There will be a tendency to form more NO_2 and O_3
(D) There will be no tendency for change because the reaction is at equilibrium.

Q.2 The standard enthalpy of formation of gaseous H_2O at 298 K is -242 kJ mol^{-1}. Calculate $\Delta H°$ at 373 K given the following values of the molar heat capacities at constant pressure
Molar heat capacity of H_2O (g) = 33.5 $JK^{-1}mol^{-1}$
Molar heat capacity of H_2 (g) = 28.8 $JK^{-1}mol^{-1}$
Molar heat capacity of O_2 (g) = 29.4 $JK^{-1}mol^{-1}$
Assume that the heat capacities are independent of temperature.
(A) 508 $kJmol^{-1}$ (B) -242 $kJmol^{-1}$ (C) -242.75 $kJmol^{-1}$ (D) None

Q.3 A reaction takes place in three steps. The rate constant are K_1, K_2 & K_3. The overall rate constant $K = \dfrac{K_1 \times K_3}{K_2}$. If energy of activation are 20, 15 and 10 kJ/mole, the overall energy of activation is
(A) 10 (B) 15 (C) 20 (D) $\dfrac{40}{3}$

Q.4 At 200°C PCl_5 dissociates as follows:
$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$
It was found that the equilibrium vapours are 62 times as heavy as hydrogen. The degree of dissociation of PCl_5 at 200°C is:
(A) 10% (B) 42% (C) 50% (D) 68%

Q.5 For the reaction
$C_2H_6(g) \rightleftharpoons C_2H_4(g) + H_2(g)$
K_P is 0.05 at 900 K. If an initial mixture comprising 20 mol of C_2H_6 and 80 mol of inert gas is passed over a dehydrogenation catalyst at 900 K, what is the equilibrium mole percentage of C_2H_6 in the gas mixture? The total pressure is kept of 0.5 bar.
(A) 4.3 (B) 9.67 (C) 8.76 (D) 72.5

Q.6 A certain radio isotope ${}^{A}_{Z}X$ ($t_{1/2}$=10 days) decays to given ${}^{A-4}_{Z-2}Y$, if two mole of ${}^{A}_{Z}X$ is kept in a sealed vessel, how much He will accumulate in 20 days at STP?
(A) 16.8 litre (B) 22.4 litre (C) 33.6 litre (D) None

Q.7 For the transformation
H_2O (l, 1 atm) to H_2O (g, 0.1 atm) ; $\Delta H_{vap.}$ = 40.668 kJ mol^{-1}
The change in entropy (Jk^{-1} mol^{-1}) is
(A) 19.14 (B) 89.89 (C) 109.03 (D) 128.17

Q.8 $Cl_2(g)$ and $O_2(g)$ are taken in the molar ratio of 2 : 7 where the following equilibrium was established:

$$2Cl_2 + 7O_2 \rightleftharpoons 2Cl_2O_7$$

At equilibrium, mole fraction of Cl_2O_7 was found to be 0.1 when the total pressure was 100 bar. In an another experiment, two gases were taken in equimolar amount under identifical condition of temperature and mole fraction of Cl_2O_7 at equilibrium was found to be 0.06. The equilibrium pressure in the new flask is
(A) 115 bar (B) 150 bar (C) 180 bar (D) 202 bar

Q.9 When sulphur in the form of S_8 is heated at 900 K, the initial pressure of 1 atm falls by 30% at equilibrium. This is because of conversion of some S_8 to S_2. The value of equilibrium constant for this reaction is

(A) 2.96 (B) 2.05 (C) 0.39 (D) 3.9

Q.10 A solution of 0.4 g sample of H_2O_2 reacted with 0.632 g of $KMnO_4$ in presence of sulphuric acid. The percentage purity of the sample of H_2O_2 is

(A) 95% (B) 85% (C) 80% (D) none of these

Q.11 For the reaction (1) and (2)

$A \rightleftharpoons B + C$

$D \rightleftharpoons 2E$

Given $K_{P_1} : K_{P_2} = 9 : 1$

If the degree of dissociation of A and D be same then the total pressure at equilibrium (1) and (2) are in the ratio.

(A) 3 : 1 (B) 36 : 1 (C) 1 : 1 (D) 0.5 : 1

Q.12 The equilibrium constant for the reaction

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

is 3.0 at 723 K and 1 atm pressure. The initial amount of water gas is 60 g and that of steam 90 g. At equilibrium the number of moles of CO_2 is

(A) 4.5 (B) 1.5 (C) 2.5 (D) 3.5

Q.13 For the reaction

$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$

the values of $\Delta H°$ and $\Delta S°$ at 298 K are 77.2 kJ mol^{-1} and 122 JK^{-1} mol^{-1} respectively. The standard equilibrium constant at the same temperature is

(A) 0.695×10^{-8} (B) 6.95×10^{-8} (C) 69.5×10^{-8} (D) 695×10^{-8}

Q.14 Ethylene is produced by

$$\underset{\text{Cyclobutane}}{C_4H_8} \xrightarrow{\Delta} 2C_2H_4$$

The rate constant is 2.48×10^{-4} sec^{-1}. In what time will the molar ratio of the ethylene to cyclobutane in reaction mixture attain the value 1?

(A) 27.25 minute (B) 28.25 minute (C) 25 minute (D) 20 minute

Q.15 Rate of formation of SO_3 in the following reaction

$$2SO_2 + O_2 \longrightarrow 2SO_3$$

is 100 kg min^{-1}. Hence rate of disappearance of SO_2 will be:

(A) 100 kg min^{-1} (B) 80 kg min^{-1} (C) 64 kg min^{-1} (D) 32 kg min^{-1}

Q.16 For a given reaction of first order, it takes 20 minutes for the concentration to drop from 1.0 mol $litre^{-1}$ to 0.6 mol $litre^{-1}$. The time required for the concentration to drop from 0.6 mol $litre^{-1}$ to 0.36 mol $litre^{-1}$ will be

(A) more than 20 minutes (B) less than 20 minutes

(C) equal to 20 minutes (D) infinity

Q.17 The reaction $N_2 + O_2 \rightleftharpoons 2NO$, follows the kinetics Rate $\propto [N_2][O_2]$. The order of reactions when both N_2 and O_2 are in small amount, N_2 is in large excess as compared to O_2 and both N_2 and O_2 are in large excess are

(A) 2, 1 and 2 (B) 2, 1 and 1 (C) 2, 1 and 0 (D) 1, 1 and 0

Q.18 The reaction: $2NO + 2H_2 \longrightarrow N_2 + 2H_2O$ has been assigned to follow following mechanism

I. $NO + NO \rightleftharpoons N_2O_2$ (fast) II. $N_2O_2 + H_2 \longrightarrow N_2O + H_2O$ (slow)

III. $N_2O + H_2 \longrightarrow N_2 + H_2O$ (fast)

The rate constant of step II is 1.2×10^{-4} mole^{-1}L min^{-1} while equilibrium constant of step I is 1.4×10^{-2}. What is the rate of reaction when concentration of NO and H_2 each is 0.5 mole L^{-1}.

(A) 2.1×10^{-7} mol L^{-1} min^{-1} (B) 3.2×10^{-6} mol L^{-1} min^{-1}

(C) 3.5×10^{-4} mol L^{-1} min^{-1} (D) none of these

Q.19 A radioactive isotope is being produced at a constant rate x. Half-life of the radioactive substance is y. After sometimes number of radioactive nuclei becomes constant, the value of this constant is

(A) $\frac{xy}{\ell n\, 2}$ (B) xy (C) $(\ell n\, 2)xy$ (D) x/y

Q.20 Rate constant, $k = 1.8 \times 10^4$ mol^{-1} L s^{-1} and $E_a = 2 \times 10^2$ kJ mol^{-1}, when $T \to \infty$, then the value of A is

(A) 1.8×10^4 kJ mol^{-1} (B) 1.8×10^4 mol^{-1} L sec^{-1}

(C) 1.8×10^4 mol L^{-1} sec^{-1} (D) 2.4×10^3 kJ mol^{-1} sec^{-1}

Q.21 PCl_5 is 40% dissociated when pressure is 2 atm it will be 80% dissociated when pressure is approximately

(A) 0.2 atm (B) 0.5 atm (C) 0.3 atm (D) 0.6 atm

Q.22 A vessel contains $H_2(g)$ at 2 atm pressure, when $H_2S(g)$ at a pressure of 4 atm is introduced into the vessel. Where reaction

$8H_2S(g) \rightleftharpoons 8H_2 + S_8(s)$

Occurs at a temperature of 1000 K. It is found that

$\left[\frac{n(H_2)}{n(H_2S)}\right]_{\text{at equilibrium}} = \left[\frac{n(H_2S)}{n(H_2)}\right]_{\text{at t=0}}$, then

(A) maximum weight of solid formed is 32 gm

(B) maximum weight of solid formed is 0.32 gm

(C) $K_p = K_cRT$

(D) $K_c = 256$

Q.23 At a certain temperature the following equilibrium is established

$CO(g) + NO_2(g) \rightleftharpoons CO_2(g) + NO(g)$

One mole of each of the four gases is mixed in one litre container and the reaction is allowed to reach equilibrium state. When excess of baryta water is added to the equilibrium mixture, the weight of white precipitate obtained is 236.4 gm. The equilibrium constant K_c of the following reaction is

(A) 1.2 (B) 2.25 (C) 2.1 (D) 3.6

Q.24 Rate of disappearance of the reactant A at two different temperatures is given by $A \rightleftharpoons B$

$\frac{-d[A]}{dt} = 2 \times 10^{-2}$ sec^{-1} [A] $- 4 \times 10^{-3}$ sec^{-1} [B] at 300 K

$\frac{-d[A]}{dt} = 4 \times 10^{-2}$ sec^{-1} [A] $- 16 \times 10^{-4}$ sec^{-1} [B] at 400 K

heat of reaction in the given temperature range, when equilibrium is set up is

(A) $\frac{2.303\times2\times300\times400}{100}\ \ell\text{og } 50$ Cal (B) $\frac{2.303\times2\times300\times400}{100}\ \ell\text{og } 250$ Cal

(C) $\frac{2.303\times2\times300\times400}{100}\ \ell\text{og } 5$ Cal (D) None

Q.25 The hydrolysis of an ester was carried out separately with 0.05 N HCl and 0.05 N H_2SO_4. Which of the following will be true?

(A) $k_{HCl} > k_{H_2SO_4}$ (B) $k_{HCl} < k_{H_2SO_4}$ (C) $k_{HCl} = k_{H_2SO_4}$ (D) $k_{H_2SO_4} = 2k_{HCl}$

Q.26 A radioactive nuclide is produced at a constant rate of α-per second. It decay constant is λ. If N_0 be the no. of nulcei at time t = 0, then maximum no. of nuclei possible are

(A) $\frac{\alpha}{\lambda}$ (B) $N_0 + \frac{\alpha}{\lambda}$ (C) N_0 (D) $\frac{\lambda}{\alpha} + N_0$

Q.27 The mechanism of the reaction

$2NO + O_2 \longrightarrow 2NO_2$ is

$NO + NO \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} N_2O_2$ (fast)

$N_2O_2 + O_2 \xrightarrow{k_2} 2NO_2$ (slow)

the rate constant for the reaction is

(A) k_2 (B) $k_2.k_1.k_{-1}$ (C) $k_2.k_1$ (D) $k_2\left(\frac{k_1}{k_{-1}}\right)$

Q.28 $CH_3 - CO - CH_3(g) \rightleftharpoons CH_3 - CH_3(g) + CO(g)$

Initial pressure of CH_3COCH_3 is 100mm when equilibrium is set up, mole fraction of CO(g) is $\frac{1}{3}$ hence k_p is

(A) 100 mm (B) 50 mm (C) 25 mm (D) 150 mm

Q.29 $X \rightleftharpoons nY$, X decomposes to give Y (in one litre vessel) if degree of dissociation is a then K_C and its unit.

(A) $\frac{n\alpha}{(1-\alpha)}$, $mol^{n-1}\ lit^{n-1}$ (B) $\frac{n\alpha}{(1-\alpha)}\ mol^n\ lit^n$

(C) $\frac{n\alpha}{(1-\alpha)}$, K_C is unit less (D) $\frac{(n\alpha)^n}{(1-\alpha)}$, $mol^{n-1}\ litre^{n-1}$

Q.30 If the ionic product of water varies with temperature as follows and the density of water be nearly constant for this range of temperature the process $H^+ + OH^- \rightleftharpoons H_2O$ is

Temp.°C	0	10	25	40	50
K_w	0.114×10^{-14}	0.292×10^{-14}	1.008×10^{-14}	2.91×10^{-14}	5.474×10^{-14}

(A) Exothermic (B) Endothermic (C) Can't say (D) none

BOMB

Q.1 For the reaction,

$2SO_3\ (g) \rightleftharpoons 2SO_2\ (g) + O_2\ (g)$ $\quad \Delta H_1^o$ = standard enthalpy change of reaction

ΔS_1^o = standard entropy at temperature **T**

$2NO_3\ (g) \rightleftharpoons 2NO_2\ (g) + O_2\ (g)$ $\quad \Delta H_2^o$ = standard enthalpy at temperature **T**

ΔS_2^o = standard entropy at temperature **T**

Find out the equilibrium constant for the reaction

$SO_2\ (g) + NO_3\ (g) \rightleftharpoons SO_3\ (g) + NO_2\ (g)$ at the same temperature in terms of above parameter.

Q.2 Given the sub shells 1s, 2s, 2p, 3p and 3d. Identify those meet the following descriptions

(a) Has *l*(azimuthal quantum no.) = 2

(b) Can have m (magnetic quantum no.) = –1

(c) Is empty in a nitrogen atom

(d) Is full in a carbon atom

(e) Can contain two electrons, both with spin $m_s = +1/2$

(f) Contains the outermost shell electrons in oxygen atom

Q.3 Rate of diffusion of ozonized oxygen is $0.4\sqrt{5}$ times that of pure oxygen. Find

(a) Percentage by mass of ozone in the ozonized sample

(b) Degree of dissociation of oxygen assuming pure O_2 in the sample initially.

Q.4 A 250 ml flask and 100 ml flask are separated by a stop cock. At 350 K, the nitric oxide in the larger flask exerts a pressure of 0.46 atm and the smaller one contains oxygen at 0.86 atm. The gases are mixed by opening the stop cock. The reaction occuring are

$$2NO + O_2 \longrightarrow 2NO_2 \rightleftharpoons N_2O_4$$

The first reaction is complete while the second one is at equilibrium. Assuming all the gases to behave ideally, calculate the K_p for the equilibrium reaction if the final total pressure is 0.37 atm.

Q.5 A container whose volume is V contains an equilibrium mixture that consists of 2 mol each of PCl_5, PCl_3 and Cl_2 (all as gases). The pressure is 30.3975 kPa and temperature is T. A certain amount of $Cl_2(g)$ is now introduced keeping the pressure and temperature constant until the equilibrium volume is 2V. Calculate the amount of Cl_2 that was added and the value of K_p.

Q.6 A balloon containing air at 27°C and 1 atm initially is filled with air further isothermally and reversibly till the pressure is 4 atm. If the initial diameter of the balloon is 1 m and the pressure at each state is proportional to diameter of the balloon, calculate the work done.

Q.7 (a) Thermal decomposition of dibromosuccinic acid (DBSA) taking place according to the following equation, obeys first order kinetics

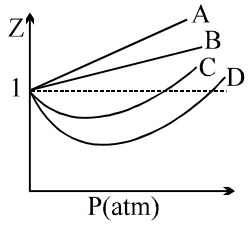
$$\begin{array}{l} CH(Br)COOH \\ | \\ CH(Br)COOH \end{array} \longrightarrow \begin{array}{l} CHCOOH \\ \| \\ C(Br)COOH \end{array} + HBr$$

The progress of reaction may be followed by means of alkali titration of the solution (reaction mixture) at various time intervals. If T_0 and T_t be the titres at zero – time and at any time t, respectively, a and a – x be the concentrations DBSA at zero time and at any time t, repectively, show that

$$\frac{T_0}{3T_0 - 2T_t} = \frac{a}{a - x}$$

(b) If the rate of a reaction doubles from 0°C to 10°C by what factor would the ratio increase when the temperature increases from 100°C to 110°C and what is the activation energy?

Q.8 Compressbility factor Z vs P plot for four real gases A, B, C & D are shown at 300 K



(a) Out of gases A and B whose molecules are larger? Justify.
(b) If slope of curve for B is 0.02 atm^{-1}, calculate Van der Waals constant b for gas B.
(c) Arrange Boyle temperatures (T) for gases A, B, C & D in increasing order.

Q.9 Surface catalysed reactions that are incorporated by the product obey the differential rate expression:

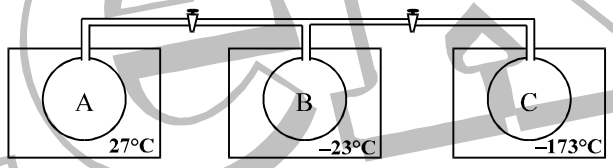
$$\frac{dy}{dt} = \frac{k[C_0 - y]}{1 + by}$$ were C_0 = initial concentration, k and b are constant

then find out the expression of $t_{1/2.}$

Q.10 The apparatus shown consists of three temperature jacketed 1 litre bulbs connected by stop cocks. Bulb A contains a mixture of $H_2O(g)$, $CO_2(g)$ and $N_2(g)$ at 27°C and a total pressure of 547.2 mm Hg. Bulb B is empty and is held at a temperature –23°C. Bulb C is also empty and is held at a temperature of –173°C. The stopcocks are closed and the volumes of lines connecting the bulbs is zero.

Given: $CO_2(g)$ converted into $CO_2(s)$ at –78°, $N_2(g)$ converted into $N_2(s)$ at –196°C & $H_2O(g)$ converted into $H_2O(s)$ at 0°C.

[Use R = 0.08 atm-litre/mole·K]



(a) The stopcock between A & B is opened and the system is allowed to come to equilibrium. The pressure in A & B is now 228 mmHg. What do bulbs A & B contain?
(b) How many moles of H_2O are in system?
(c) Both stopcocks are opened and the system is again allowed to equilibrium. The pressure throughout the system is 45.6 mmHg. What do bulbs A, B and C contain?
(d) How many moles of N_2 are in the system?

ANSWER KEY

SPARKLES

Q.1	B	Q.2	C	Q.3	B	Q.4	D	Q.5	C	Q.6	C	Q.7	D
Q.8	A	Q.9	A	Q.10	B	Q.11	B	Q.12	B	Q.13	B	Q.14	A
Q.15	B	Q.16	C	Q.17	A	Q.18	A	Q.19	A	Q.20	B	Q.21	A
Q.22	D	Q.23	B	Q.24	C	Q.25	A	Q.26	A	Q.27	D	Q.28	B
Q.29	D	Q.30	A										

BOMB

Q.1 $K = \exp - \left\{ \dfrac{\left(\Delta H_2^o - \Delta H_1^o\right) - T\left(\Delta S_2^o - \Delta S_1^o\right)}{2RT} \right\}$

Q.2 (a) 3d (b) 2p, 3p, 3d (c) 3s, 3p and 3d (d) 1s & 2s
(e) 2p, 3p and 3d (f) 2p , 2s

Q.3 60%, 0.6 Q.4 0.64 atm Q.5 20/3 moles Q.6 1.015×10^4 kJ

Q.7 (b) $k_2/k_1 = 1.454$, 10.64 kcal Q.8 (a) A > B, (b) 0.492 L/mol, (c) $T_A < T_B < T_C < T_D$

Q.9 $t_{1/2} = \dfrac{1}{k}\left[(1 + C_0 b) ln 2 - \dfrac{C_0 b}{2} \right]$

Q.10 (a) Bulb A : $N_2(g)$, $CO_2(g)$
Bulb B: $N_2(g)$, $CO_2(g)$, $H_2O(s)$
(b) No. of mole of $H_2 = 0.0025$
(c) Bulb A : $N_2(g)$
Bulb B : $N_2(g)$, $H_2O(s)$
Bulb C : $N_2(g)$, $CO_2(s)$
(d) Total no. of mole of N_2 in system = 0.013

