CHEMISTRY

BOOKS - MTG IIT JEE FOUNDATION

CHEMICAL EQUILIBRIUM

Illustrations

1. For the following reversible reaction, `N_2 + 3H_2 represent the dynamic equilibrium graphically.

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2. For the reactions,

$N_2 + 3H_2 \rightarrow 2NH_3$

and $\frac{1}{2}N_2 + \frac{3}{2}H_2 \rightarrow NH_3$

write down the expression for equilibrium constant K_1 and K_2. How is K_1 related to K_2?

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3. An equilibrium system for the reaction between hydrogen and iodine to give hydrogen iodide at 670 K in a 5 litre flask contains 0.4 mole of hydrogen, 0.4 mole of iodine and 2.4 moles of hydrogen iodide. Calculate the equilibrium constant.

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4. In the following gaseous phase equilibrium in 5 L flask at constant temperature, number of moles of SO_2 and SO_3 are equal. Calculate number of moles of O_2 at equilibrium.

$2SO_2 + O_2 \rightarrow 2SO_3, K_c = 5$

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5. For a reaction $X \rightarrow Y$, heat of reaction is $+83.68kJ$, energy of reactant X is 167.36 kJ and energy of activation is 209.20 kJ. Calculate (i) threshold energy (ii) energy of product Y and (iii) energy of activation for the reverse reaction $(Y \rightarrow X)$.

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6. Classify the following reactions as endothermic or exothermic.

(1) $N_{2(g)} + O_{2(g)} + 180.5kJ \rightarrow 2NO_{(g)}$

(2) $4NH_{3(g)} + 5O_{2(g)} - 905.6kJ \rightarrow 4NO_{(g)} + 6H_2O_{(g)}$

(3) $N_2O_4\left(H^\circ = 9.16kJmol^{-1}\right) \rightarrow 2NO_2\left(H^\circ = 33.2kJmol^{-1}\right)$

(4) $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}\left(H^\circ_{NH_3} = -46.1kJmol^{-1}\right)$

Note : Enthalpy of element is taken as zero $\left(H^\circ_{N_2} = 0\right), \left(H^\circ_{H_2} = 0\right)$

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7. Consider the following reversible reaction at equilibrium

`2H_(2)O_((g)) What conditions will lead to maximum decomposition of

$H_2O_{(g)}$?

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8. For the water-gas shift reaction :

`CO_(g)) + H_(2)O_((g)) does the amount of H_2 in an equilibrium mixture increase or decrease when the temperature is increased? How does K change when the temperature is decreased?

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9. Does the number of moles of reaction products increase, decrease or remain the same when each of the following equilibria is subjected to a decrease ($\downarrow$) in pressure (by increasing ($\uparrow$) volume)?

(a) `2CO_((g)) (b) `N_2O_(4(g)) (c) `CaO_((s)) + CO_(2(g)) (d) `3Fe_((s)) + 4H_2O_((g))

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10. For the water gas reaction,

$C_{(s)} + H_2O_{(g)} \rightarrow CO_{(g)} + H_{2(g)}$ the standard Gibbs energy for the reaction at 1000 K is $-8.1kJmol^{-1}$. Calculate its equilibrium constant.

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Solved Examples

1. For the following chemical equation, write expression for equilibrium constants K_c and `K_p 2NO_2 Also write their proper units.

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2. Calculate the equilibrium concentration ratio of C to A, if 2.0 mol each of A and B were allowed to come to equilibrium at 300 K.

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3. In the industrial synthesis of hydrogen, mixtures of CO and H_2 are enriched in H_2 by allowing the CO to reacts with steam. The chemical equation for this so called water - gas shift reaction is

`CO_((g)) + H_2O_((g)) If at $200^\circ C, p_{CO_2} = 0.2atm, p_{H_2} = 0.1atm, p_{CO} = 2atm, p_{H_2O} = 0.01atm.$ Calculate K_c.

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4. Classify the following reactions according to their extent of taking place.

(a) `2H_2 + O_2 (b) `2H_2O (c) `H_2 + I_2 (d) `N_2O_4

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5. At $46^\circ C$, K_p for the reaction,

`N_2O_(4(g))

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6. 0.15 mole of CO taken in 2.5 L flask is maintained at 750 K along with a catalyst so that the following reaction can take place.

`CO_((g)) + 2H_(2(g)) Hydrogen is introduced until the total pressure of the system is 8.5 atm at equilibrium and 0.08 mole of methanol is formed. Calculate K_c for the above equilibrium.

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7. The equilibrium constant for the reaction :`2SO_(2(g)) + O_(2(g)) Find the value of K_p for each of the following reactions at the same temperature :

(i) `SO_(2(g)) + 1/2 O_(2(g)) (ii) `SO_(3(g)) (iii) `3SO_(2(g)) + O_(2(g))

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8. A mixture of H_2, N_2 and NH_3 with molar is concentrations $5.0 \times 10^{-3} molL^{-1}, 4.0 \times 10^{-3} molL^{-1}$ at and $2.0x10^{-3} molL^{-1}$

respectively was prepared and heated to 500 K. The value of K_c for the reaction :

`3H_(2(g)) + N_(2(g))

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9. The degree of dissociation of PCl_5 at a certain temperature and under atmospheric pressure is 0.2. Calculate the pressure at which it will be half dissociated at the same temperature.

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10. Calculate ΔG° and the equilibrium constant for the formation of NO_2 from $NO$and O_2 at `298 K NO_((g)) + 1/2 O_(2(g)) Where

$\Delta_f G^\circ(NO_2) = 52.0 kJ mol^{-1}$

$\Delta_f G^\circ(NO) = 87.0 kJ mol^{-1}$

$\Delta_f G^\circ(O_2) = 0 kJ mol^{-1}$

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Exercise Multiple Choice Questions

1. For a reaction in the equilibrium state, the rate constants for the forward and backward reactions are 2.38×10^{4} and 8.15×10^{-5} respectively. What is the value of the equilibrium constant?

A. 2.92

B. 3.84

C. 3.05

D. 10^{-3}

Answer: A

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2. The equilibrium constant for the reaction, `N_(2(g)) + O_(2(g))

A. 40×10^{-4}

B. 4×10^{-4}

C. 4×10^{-3}

D. the data is insufficient.

Answer: B

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3. A quantity of PCl_5 was heated in a $10dm^3$ vessel at $250^\circ C$. At equilibrium, the vessel contains 0.1 mole of PCl_5 and 0.2 mole of Cl_2.The equilibrium constant for the reaction is

A. 0.05

B. 0.02

C. 0.03

D. 0.04

Answer: D

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4. Nitric oxide reacts with bromine and gives nitrosyl bromide as per reaction given below:

`2NO_((g)) + Br_(2(g)) When 0.087 mol of NO and 0.0437 mol of Br_2 are mixed in a closed container at constant temperature, 0.0518 mol of $NOBr$ is obtained at equilibrium. The equilibrium amount of nitric oxide and bromine are respectively

A. 0.0352 mol, 0.0352 mol

B. 0.0718 mol, 0.0178 mol

C. 0.0352 mol, 0.0178 mol

D. 0.0718 mol, 0.0352 mol

Answer: C

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5. Sulphide ion in alkaline solution reacts with solid sulphur to form polysulphide ions having formula S_2^{2-}, S_3^{2-}, S_4^{2-} and so on. The equilibrium constant for the formation of S_2^{2-} is 12 and for the formation of S_3^{2-} is 136, both from S and S^{2-}. What is the equilibrium constant for the formation of S_3^{2-}. from S_2^{2-} and S?

A. 12

B. 11

C. -0.094

D. 16

Answer: B

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6. For the reaction, `2NO_(2(g)) $R = 0.0831$ kJ/mol K

When K_p and K_c are compared at $184^\circ C$ it is found that

A. K_p is greater than K_c

B. K_p is less than K_c

C. $K_p = K_c$

D. whether K_p is greater than, less than or equal to K_c depends upon the total gas pressure.

Answer: A

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7. At constant temperature, the equilibrium constant (K_p) for the decomposition reaction,

`N_2O_(4(g)) $K_p = \left(4x^2 + P\right) / \left(1 - x^2\right)$, where P= pressure, x = extent of decomposition. Which one of the following statements is true?

A. K_p increases with increase of P.

B. K_p increases with increase of x.

C. K_p increases with decrease of x.

D. K_p remains constant with change in P and x.

Answer: D

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8. Favourable conditions for manufacture of ammonia by the reaction,

`N_2 + 3H_2

A. low temperature and low pressure

B. low temperature and high pressure

C. high temperature and low pressure

D. high temperature and high pressure.

Answer: B

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9. The reaction quotient (Q) at equilibrium is

A. $= 1$

B. $= K$

C. $> K$

D. $< K$

Answer: B

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10. For the reaction `a + b

A. 2

B. 9

C. 4

D. 3

Answer: C

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11. K_c for $A + B \Leftrightarrow C + D$ is 10 at $25^\circ C$. If a container contains 1, 2, 3, $4\ mol/litre$ of A, B, C and D respectively at $25^\circ C$, the reaction shell proceed:

A. proceed from left to right

B. proceed from right to left

C. be at equilibrium

D. none of the above.

Answer: A

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12. At equilibrium, the amount of HI in a 3 litre vessel was 12.8 g. Its equilibrium concentration is

A. 4.267 M

B. 0.033 M

C. 0.1 M

D. 0.2 M

Answer: B

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13. Which one is correct representation for

`2SO_3

A. $K_p = \frac{(p_{SO_2})^2 (p_{O_2})}{(p_{SO_3})^2}$

B. $K_c = \frac{[SO_2]^2 [O_2]}{[SO_3]^2}$

C.

$$K_p = \frac{(\text{mole of} SO_2)^2 \times (\text{mole of} O_2)}{(\text{mole of} SO_3)^2} \times \left[\frac{p}{\text{total mole at equilibrium}}\right]$$

D. All of the above

Answer: D

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14. If K_1 and K_2 are the respective equilibrium constants for the two reactions,

$XeF_{6(g)} + H_2O_{(g)} \rightarrow XeOF_{4(g)} + 2HF_{(g)}$

$XeO_{4(g)} + XeF_{6(g)} \rightarrow XeOF_{4(g)} + XeO_3F_{2(g)}$

The equilibrium constant for the reaction,

$XeO_{4(g)} + 2HF_{(g)} \rightarrow XeO_3F_{2(g)} + H_2O_{(g)}$ is

A. K_1 / K_2

B. $K_1 K_2$

C. K_2 / K_1

D. $K_1 K_2^2$

Answer: C

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15. Which one is reversible process?

A. Melting of ice at $10^\circ C$

B. Mixing of two gases by diffusion

C. Evaporation of water at $100^\circ C$ and 1 atm pressure

D. None of the above

Answer: C

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16. The equilibrium constant of the reaction, $H_2 + I_2 \Leftrightarrow 2HI$ is 50. If the volume of the container is reduced to half of its original value, the value of equilibrium constant will be

A. 25

B. 50

C. 75

D. 100

Answer: B

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17. In an-aqueous solution of volume 500 ml , when the reaction of $2Ag^+ + Cu \Leftrightarrow Cu^{2+} + 2Ag$ reached equilibrium , the $\left[Cu^{2+}\right]$ was x M. when 500 ml of water if further a added at the equilibrium $\left[Cu^{2+}\right]$ will be

A. $2xM$

B. xM

C. between xM and $\frac{x}{2}M$

D. less than $\frac{x}{2}M$

Answer: D

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18. Which of the following relative value of k_f (rate constant of forward reaction) and k_b (rate constant of backward reaction) results in an equilibrium mixture that contain large amount of reactants and small amounts of products?

A. $k_f > k_b$

B. $k_b = k_f$

C. $k_f < k_b$

D. $k_b > > > k_f$

Answer: C

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19. The degree of dissociation of N_2O_4, $N_2O_{4(g)} \rightarrow 2NO_{2(g)}$, at temperature T and total pressure P is α. Which of the following expressions is correct for the equilibrium constant of this reaction at this temperature and pressure?

A. $2\alpha / \left(1 - \alpha^2\right)$

B. $\alpha^2 P / (1 - \alpha)$

C. $4\alpha^2 / \left(1 - \alpha^2\right)$

D. $4\alpha^2 P / \left(1 - \alpha^2\right)$

Answer: D

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20. Equilibrium constant for the reaction,

$H_2O_{(g)} + CO_{(g)} \rightarrow H_{2(g)} + CO_{2(g)}$ is 81. If the velocity constant of the forward reaction is $162 Lmol^{-1}s^{-1}$, what is the velocity constant (in $Lmol^{-1}s^{-1}$) for the backward reaction?

A. 13122

B. 2

C. 261

D. 243

Answer: B

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21. 5 moles of PCl_5 are heated in a closed vessel of 5 litre capacity. At equilibrium $40\,\%$ of PCl_5 is found to be dissociated. What is the value of K_c ?

A. 0.266 M

B. 0.133 M

C. 2.5 M

D. 0.20 M

Answer: A

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22. For the reaction,

$CO_{(g)} + H_2O_{(g)} \Leftrightarrow CO_{2(g)} + H_{2(g)}$

at a given temperature, the equilibrium amount of $CO_{2(g)}$ can be increased by:

A. adding a suitable catalyst

B. adding an inert gas

C. decreasing the volume of the container

D. increasing the amount of CO_g

Answer: D

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23. What is the equilibrium expression for the reaction $P_4(s) + 50_2(g) \Leftrightarrow P_4O_{10}(s)$

A. $K_c = \frac{[P_4O_{10}]}{[P_4][O_2]^5}$

B. $K_c = \frac{1}{[O_2]^5}$

C. $K_c = [O_2]^5$

D. $K_c = \frac{[P_4O_{10}]}{5[P_4][O_2]}$

Answer: B

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24. When an inert gas is introduced into the system $2HI \rightarrow H_2 + I_2$, the degree of dissociation of HI gets'

A. suppressed

B. unchanged

C. increased

D. doubled.

Answer: B

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25. Consider the reaction $A_{2(g)} \rightarrow 2A_{(g)}$. The equilibrium constants for the reaction at 500 K and 600 K are 2×10^{-70} and 3.1×10^{-5} respectively. The above reaction will be

A. fast

B. slow

C. endothermic

D. exothermic.

Answer: C

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26. If a chemical reaction is at equilibrium, it means that

A. the reactants are completely transformed into the products

B. product formation is minimum

C. equal amounts of reactants and products are present

D. the rates of forward and backward reactions are equal.

Answer: D

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27. The active mass of a solid

A. is always zero

B. is always infinity

C. is always one

D. would depend on the nature of the solid.

Answer: C

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28. A reaction flask contained 0.01 mole of As_2S_3 and 0.01 mole of H_2 to attain equilibrium at 700 K.

$As_2S_{3(g)} \rightarrow 2As_{(s)} + 3H_2S_{(g)}$

Evolved H_2S gas when passed through excess of $CuSO_4$ solution gives 0.005 moles of CuS precipitate. What is the K_p for the given reaction?

A. 0.05

B. $(0.005)^3$

C. 1

D. 2

Answer: C

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29. In a reversible chemical reaction having two reactants in equilibrium, if the concentration of the reactants are doubled then the equilibrium constant will :

A. also be doubled

B. be halved

C. become one fourth

D. remain the same.

Answer: D

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30. The equilibrium constant K_{p_1} and K_{p_2} for the reactions $X \Leftrightarrow 2Y$ and $Z \Leftrightarrow P + Q$, respectively are in the ratio of $1:9$. If the degree of dissociation of X and Z be equal, then the ratio of total pressure at these equilibrium is:

A. $1:1$

B. $1:3$

C. $1:9$

D. $1:36$

Answer: D

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31. The equilibrium constant for the following reaction $aA + bB \rightarrow cC + dD$is K. The equilibrium constant of the reaction $ncC + ndD \rightarrow naA + nbB$, will be

A. K^n

B. $\frac{n}{K}$

C. $n.\ K$

D. $\frac{1}{K^n}$

Answer: D

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32. At 550 K, the Kc for the following reaction is $10^4 mol^{-1}L.\ X(g) + Y(g) \rightarrow Z(g)$ At equilibrium, it was observed that $[X] = \frac{1}{2}[Y] = \frac{1}{2}[Z]$. What is the value of $[Z]\left(\text{in } mol^{-1}L\right)$ at equilibrium ?

A. 2×10^{-4}

B. 10^{-4}

C. 2×10^4

D. 10^4

Answer: A

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33. At constant temperature, mole number of which equation does not change on increasing volume?

A. $N_{2(g)} + O_{2(g)} \Rightarrow 2NO_{(g)}$

B. $2H_{2(g)} + O_{2(g)} \Rightarrow 2H_2O_{(g)}$

C. $N_{2(g)} + 3H_{2(g)} \Rightarrow 2NH_{3(g)}$

D. $2SO_{2(g)} + O_{2(g)} \Rightarrow SO_{3(g)}$

Answer: A

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34. According to law of mass action, the rate of a reaction is directly proportional to

A. molarities of the reactants

B. normalities of the reactants

C. molalities of the reactants

D. mole fractions of the reactants

Answer: A

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35. In which of the following reactions, the equilibrium constant will have no units of concentration ?

A. $NO_{(g)} \Rightarrow \frac{1}{2}N_{2(g)} + \frac{1}{2}O_{2(g)}$

B. $H_{2(g)} + I_{2(g)} < \Rightarrow 2HI_{(g)}$

C. $CO_{(g)} + H_2O_{(g)} < \Rightarrow CO_{2(g)} + H_{2(g)}$

D. In all the above reactions.

Answer: D

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36. In an exothermic reaction, a 10° rise in temperature will

A. decrease the value of equilibrium constant

B. double the value of K_c

C. not produce any change in K_c

D. produce some increase in K_c

Answer: A

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37. If pressure is increased on the equilibrium

$\text{Ice} \Leftrightarrow Water$

which of the following occurs?

A. More of the ice melts

B. More of the ice is formed.

C. There is no change in the amounts of ice and water.

D. Some water gets vaporised

Answer: A

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38. In a chemical equilibrium, the rate constant for the backward reaction is 7.5×10^{-4} and the equilibrium constant is 1.5 the rate constant for the forward reaction is:

A. 5×10^{-4}

B. 2×10^{-3}

C. 1.125×10^{-3}

D. 9.0×10^{-4}

Answer: C

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39. At $448^{\circ}C$, the equilibrium constant (K) for the reaction `H_(2(g)) + I_(2(g))

A. reaction is in equilibrium

B. reaction will proceed in the forward direction

C. reaction will proceed in the backward direction

D. no reaction will take place.

Answer: B

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40. In the given reaction

`2X_((g)) + Y_((g)) which combination of pressure and temperature will give the highest yield of Z at equilibrium?

A. 1000 atm and $200^\circ C$

B. 500 atm and $500^\circ C$

C. 500 atm and $100^\circ C$

D. 1000 atm and $500^\circ C$

Answer: A

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41. An endothermic reaction $A \to B$ has activation energy equal to $40 kcal \text{mol}^{-1}$ and heat of reaction is $15 kcal \text{mol}^{-1}$. The activation energy of the reaction $B \to A$ is

A. 25 kcal

B. 45 kcal

C. 65 kcal

D. 30 kcal

Answer: A

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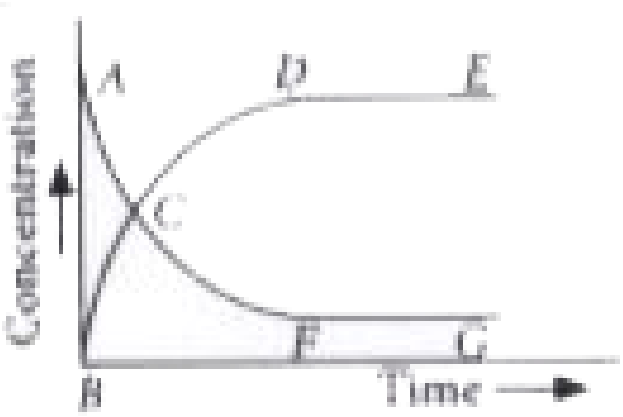
42. Reversible reaction is studied graphically as shown in the given figure.



`N_2O_4

Select the correct statements out of I, II and III.

I. Reaction quotient has maximum value at point A.

II. Reaction proceeds left to right at a point when $[N_2O_4] = [NO_2] = 0.1M.$

III. $K_c = Q$ when point D or F is reached.

A. I, II

B. II, III

C. I, III

D. I, II, III

Answer: B

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43. For a reaction $2A \rightarrow P$, which of the equilibrium concentration correspond to K_c value for 0.01 moles of P and 0.1 moles of A at equilibrium?

A. $0.04, 0.2$

B. $0.18, 0.3$

C. $0.08, 0.2$

D. $0.16, 0.8$

Answer: A

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44. In a reversible reaction, catalyst

A. increases the rate of the forward reaction

B. decreases the rate of the backward reaction

C. increases the rates of forward and backward reactions equally

D. alters the equilibrium constant of the reaction.

Answer: C

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45. The equilibrium constant K for the reaction, `HA + B

A. 10^{-3}

B. 10^{-5}

C. 10^{7}

D. 10^3

Answer: D

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46. In the equilibrium reaction, `A + B

A. The reaction is exothermic.

B. The reaction is endothermic.

C. The reaction has ΔH of $20 kcal mol^{-1}$.

D. Both (a) and (c).

Answer: B

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47. Which one of the following is homogeneous?

A. $H_2O_{(l)} < \Rightarrow H_2O_{(g)}$

B. $H_2O_{(s)} < \Rightarrow H_2O_{(l)}$

C. $N_{2(g)} + 3H_{2(g)} < \Rightarrow 2NH_{3(g)}$

D. $CaCO_{3(s)} < \Rightarrow CaO_{(s)} + CO_{2(g)}$

Answer: C

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48. The value of log K_p for the reaction `N_(2(g)) + 3H_(2(g))

A. 4.3

B. 5.8

C. 6.5

D. 3.3

Answer: B

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49. What concentration of CO_2 be in equilibrium with $2.5 \times 10^{-2} \text{mol litre}^{-1}$ of CO at $100^\circ C$ for the reaction

`FeO_((s)) + CO_((g))

A. 1×10^{-4}

B. 2.5×10^{-2}

C. 5×10^{-2}

D. 12.5×10^{-2}

Answer: D

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50. The reaction $H_{2(g)} + I_{2(g)} \rightarrow 2HI_{(g)}$ does not proceed to completion because it is

A. exothermic

B. endothermic

C. reversible

D. HI formed is unstable.

Answer: C

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Exercise Match The Following

1.

List-I	List-II
(P) $CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$	(1) Heterogeneous
(Q) $PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$	(2) Unitless
(R) $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$	(3) Atm
(S) $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$	(4) $(Atm)^{-2}$

A. $P-1, Q-4, R-2, S-1,3$

B. $P-1,2, Q-3, R-1,3S-2$

C. $P-3,4, Q-2,4, R-2,4, S-3$

D. $P-1,3, Q-3, R-2, S-4$

Answer: D

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2.

List-I	List-II
(P) $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ (endothermic)	(1) Forward shift by rise in pressure
(Q) $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$ (exothermic)	(2) Unaffected by change in pressure
(R) $N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$ (endothermic)	(3) Forward shift by rise in temperature
(S) $PCl_{5(g)} + Cl_{2(g)} \rightleftharpoons PCl_{5(g)}$ (endothermic)	(4) Forward shift by lowering the temperature

A. $P-1,3, Q-1,4, R-2,3, S-1,3$

B. $P-1,4, Q-1,3, R-2,3, S-4$

C. $P-2, Q-1,4, R-3, S-1,3$

D. $P-3, Q-1,2, R-4, S-2$

Answer: A

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List-I	List-II
(P) $Q = K$	(1) Reaction is nearer to completion
(Q) $Q < K$	(2) Reaction is not at equilibrium
(R) $Q > K$	(3) Reaction is fast in forward direction
(S) $Q >>> 1$	(4) Reaction is at equilibrium

3.

A. $P-1,3, Q-2, R-3, S-4$

B. $P-2,3, Q-4, R-2, S-3$

C. $P-4, Q-2,3, R-2, S-1,2$

D. $P-3, Q-1,3, R-4, S-2$

Answer: C

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List-I	List-II
(P) Reaction is reversed	(1) $\sqrt{K}$
(Q) Reaction is divided by 2	(2) K^2
(R) Reaction is multiplied by 2	(3) $1/K$
(S) Reaction is divided into 2 steps	(4) $K = K_1 \times K_2$

4.

A. $P-3, Q-1, R-2, S-4$

B. $P-3, Q-2, R-1, S-4$

C. $P-4, Q-2, R-3, S-1$

D. $P-2, Q-3, R-1, S-4$

Answer: A

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List-I	List-II
(P) $N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$ – heat	(1) $K_c < K_p$
(Q) $PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$ – heat	(2) Units of K_T are $(atm)^{-2}$
(R) $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ + heat	(3) With increase in temperature, K_c increases
(S) $C_{(s)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + H_{2(g)}$ – heat	(4) Equilibrium is unaffected by pressure

5.

A. $P-1,2, Q-3, R-4, S-2$

B. $P-3,4, Q-1,3, R-2, S-1,3$

C. $P-1,3, Q-2,3, R-1, S-3,4$

D. $P-1,4, Q-1,2, R-2, S-1$

Answer: B

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Exercise Assertion Reason Type

1. Assertion : The equilibrium of the reaction `A_((g)) Reason : Change of volume, changes the activation energy.

A. If both assertion and reason are true and is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason are false.

Answer: C

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2. Assertion : Greater the value of K_p for a reaction lesser is the ΔG value.

Reason : ΔG value determines the spontaneity of the reactions.

A. If both assertion and reason are true and is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason are false.

Answer: B

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3. Assertion : Chemical equilibrium represents a state of a reversible reaction in which properties of the system (pressure, concentration etc.) become constant under the given set of conditions.

Reason : The chemical equilibrium is a state of rest in which opposite reactions stop.

A. If both assertion and reason are true and is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason are false.

Answer: C

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4. Assertion : If $Q_c < K_c$ the reaction proceeds in forward direction.

Reason : K_c is independent of initial concentrations of reactants.

A. If both assertion and reason are true and is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason are false.

Answer: B

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5. Assertion : `H_(2(g)) + I_(2(g)) Increase in pressure does not cause a shift in equilibrium for the formation of HI.

Reason : Formation of HI is an endothermic reaction.

A. If both assertion and reason are true and is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason are false.

Answer: B

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6. Assertion : For a gaseous reaction, $2A \rightarrow B$, the equilibrium constant K_p is less than K_c.

Reason : K_p is related to K_c as $K_p = K_c(RT)^{\Delta n_g}$

A. If both assertion and reason are true and is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason are false.

Answer: A

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7. Assertion : Equilibrium is dynamic in nature.

Reason : Equilibrium can be attained from either direction.

A. If both assertion and reason are true and is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason are false.

Answer: B

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8. Assertion: Reaction quotient of a reaction at any time decides the direction in which the reaction will proceed.

Reason : The value of reaction quotient cannot be greater than the equilibrium constant.

A. If both assertion and reason are true and is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason are false.

Answer: C

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9. Assertion : If standard free energy change of a reaction is zero, this implies that equilibrium constant of the reaction D is unity.

Reason : For a reaction in equilibrium, in equilibrium constant is always unity.

A. If both assertion and reason are true and is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason are false.

Answer: C

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10. Assertion : The equilibrium constant is fixed and characteristics for any given chemical reaction at a specified temperature.

Reason : The equilibrium constant for an exothermic reaction decreases as the temperature increases.

A. If both assertion and reason are true and is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason are false.

Answer: B

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Exercise Comprehension Type

1. The numerical value of equilibrium constant is very important because it helps us to know whether we expect a reaction mixture at equilibrium to contain a high or a low concentration of products. Equilibrium constant helps us to predict the extent of reaction, direction of reaction

and to calculate equilibrium concentrations.

The equilibrium constant for a reaction

`H_(2(g)) + 1/2 O_(2(g))

A. concentration of products will be high

B. concentrations of reactants will be high

C. concentration of both reactants and products will be equal.

D. reaction proceeds to very small extent.

Answer: A

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2. The numerical value of equilibrium constant is very important because it helps us to know whether we expect a reaction mixture at equilibrium to contain a high or a low concentration of products. Equilibrium constant helps us to predict the extent of reaction, direction of reaction and to calculate equilibrium concentrations.

For the reaction `H_(2(g)) + I_(2(g))

A. be at equilibrium

B. move in forward direction

C. move in backward direction

D. cannot predict.

Answer: B

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3. The numerical value of equilibrium constant is very important because it helps us to know whether we expect a reaction mixture at equilibrium to contain a high or a low concentration of products. Equilibrium constant helps us to predict the extent of reaction, direction of reaction and to calculate equilibrium concentrations.

The equilibrium constant for the reaction `N_(2(g)) + 3H_(2(g))

A. $0.25 mol L^{-1}$

B. $0.11 mol L^{-1}$

C. $2.5 molL^{-1}$

D. $3.84 molL^{-1}$

Answer: D

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4. Ammonia is manufactured according to the following reaction

`N_(2(g)) + 3H_(2(g)) During preparation the pressure and temperature are maintained at 200 atm and $500^{\circ} C$ respectively inside the chamber. The reaction is carried out in presence of Fe catalyst and known as Haber's process.

If K_c for the reaction is $594.75 molL^{-1}$, then the value of K_p will be

A. 5.94×10^{-5}

B. 2.42×10^{-3}

C. 1.47×10^{-1}

D. 1.47×10^{-3}

Answer: C

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5. Ammonia is manufactured according to the following reaction

`N_(2(g)) + 3H_(2(g)) During preparation the pressure and temperature are maintained at 200 atm and $500^{\circ}C$ respectively inside the chamber. The reaction is carried out in presence of Fe catalyst and known as Haber's process.

For the given reaction, yields of ammonia at temperature T_1, T_2 and T_3 are found to be $40\,\%, 60\,\%$ and $80\,\%$. Then for temperature T_1, T_2 and T_3 the correct option is

A. $T_3 > T_2 > T_1$

B. $T_1 > T_2 > T_3$

C. $T_1 = T_2 = T_3$

D. nothing could be predicted.

Answer: B

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6. Ammonia is manufactured according to the following reaction

`N_(2(g)) + 3H_(2(g)) During preparation the pressure and temperature are maintained at 200 atm and $500^{\circ}C$ respectively inside the chamber. The reaction is carried out in presence of Fe catalyst and known as Haber's process.

If K_c for the reaction is $594.75 molL^{-1}$, then the value of K_c for the decomposition of NH_3,

`2NH_(3(g))

A. $\sqrt{594.75}$

B. $(594.75)^2$

C. $1/594.75$

D. $1/(594.75)^2$

Answer: C

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7. In heterogeneous equilibrium, involving gaseous constituents both K_p and K_c can be calculated. Consider a reaction

`aA_((g)) + bB_((g)) $\Delta n = (c+d) - (a+b)$

$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}, K_p = \frac{pC^c \times PD^d}{p_A^a \times pB^b}$

K_p and K_c are related as, $K_p = K_c(RT)^{\Delta n_g}$

Which of the following have, $K_p = K_c$?

(i) `H_(2(g)) + I_(2(g)) (ii) `N_(2(g)) + O_(2(g)) (iii) `2NO_((g)) + Cl_(2(g)) (iv) `2SO_(2(g)) + O_(2(g))

A. (i) and (ii)

B. (ii) and (iii)

C. (iii) and (iv)

D. (i) and (iv)

Answer: A

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8. In heterogeneous equilibrium, involving gaseous constituents both K_p and K_c can be calculated. Consider a reaction

`aA_((g)) + bB_((g)) $\Delta n = (c+d) - (a+b)$

$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}, K_p = \frac{pC^c \times PD^d}{p_A^a \times pB^b}$

K_p and K_c are related as, $K_p = K_c(RT)^{\Delta n_g}$

The unit of equilibrium constant for,

`H_(2(g)) + I_(2(g))

A. $molL^{-1}$

B. mol^2L^{-1}

C. $Lmol^{-1}$

D. none of these.

Answer: D

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9. In heterogeneous equilibrium, involving gaseous constituents both K_p and K_c can be calculated. Consider a reaction

`aA_((g)) + bB_((g)) $\Delta n = (c+d) - (a+b)$

$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}, K_p = \frac{pC^c \times PD^d}{p_A^a \times pB^b}$

K_p and K_c are related as, $K_p = K_c(RT)^{\Delta n_g}$

For $CaCO_{3(s)}\, CaO_{(s)} + CO_{2(g)}$, K_p / K_c is equal to

A. RT

B. $1/RT$

C. $\frac{1}{(RT)^2}$

D. $(RT)^2$

Answer: A

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10. In heterogeneous equilibrium, involving gaseous constituents both K_p and K_c can be calculated. Consider a reaction

`aA_((g)) + bB_((g)) $\Delta n = (c+d) - (a+b)$

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}, K_p = \frac{pC^c \times PD^d}{p_A^a \times pB^b}$$

K_p and K_c are related as, $K_p = K_c(RT)^{\Delta n_g}$

Which of the following have same units of K_p?

(i) `NH_3HS_((s)) (ii) `PCl_(5(g)) (iii) `AB_(2(g)) (iv)`2NH_(3(g))

A. (i) and (ii)

B. (ii) and (iii)

C. (iii) and (iv)

D. (i), (ii) and (iii)

Answer: B

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11. Equilibrium is affected by several factors like concentration, pressure or temperature. The addition of catalyst or addition of inert gas can also affect the equilibrium. The effect of change in temperature, pressure and concentration on equilibrium can be explained and predicted by Le-Chatelier's principle.

Dilute HCl is added to the following equilibrium at constant temperature

`CH_3COOH

A. concentration of CH_3COO^- will increase

B. concentration of CH_3COO^- will decrease

C. equilibrium constant will increase

D. equilibrium constant will decrease.

Answer: B

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12. Equilibrium is affected by several factors like concentration, pressure or temperature. The addition of catalyst or addition of inert gas can also affect the equilibrium. The effect of change in temperature, pressure and concentration on equilibrium can be explained and predicted by Le-Chatelier's principle.

The mixture containing the following equilibrium `N_2O_4

A. increase in the concentration of N_2O_4

B. increase in formation of NO_2

C. no change in the concentration of NO_2 or N_2O_4

D. change in equilibrium constant.

Answer: A

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13. Equilibrium is affected by several factors like concentration, pressure or temperature. The addition of catalyst or addition of inert gas can also

affect the equilibrium. The effect of change in temperature, pressure and concentration on equilibrium can be explained and predicted by Le-Chatelier's principle.

Consider the reaction,

`N_(2(g)) + 3H_(2(g)) If we increase the temperature,

A. concentration of N_2 decreases

B. concentration of H_2 decreases

C. concentration of NH_3decreases

D. concentration of NH_3 increases.

Answer: C

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14. Equilibrium is affected by several factors like concentration, pressure or temperature. The addition of catalyst or addition of inert gas can also affect the equilibrium. The effect of change in temperature, pressure and concentration on equilibrium can be explained and predicted by Le-

Chatelier's principle.

A and B are gaseous substances which react reversibly to give two gaseous substances C and D, accompanied by libration of heat. At equilibrium, it is observed that $K_p = K_c$. The equilibrium cannot be disturbed by

A. adding A

B. adding D

C. increasing temperature

D. increasing pressure.

Answer: D

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Exercise Integer Numerical Value Type

1. For the reaction :

$2A \rightarrow B + C$

At a given time, the concentration of reaction mixture is $[A] = [B] = [C] = 3 \times 10^{-4} M$. The value of reaction quotient for the reaction is'

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2. A sample of $HI(g)$ is placed in flask at a pressure of $0.2 atm$. At equilibrium. The partial pressure of $HI(g)$ is $0.04 atm$. What is K_p for the given equilibrium?

$2HI(g) \Leftrightarrow H_2(g) + I_2(g)$

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3. For the reaction involving decomposition of ammonia to form hydrogen and nitrogen gases, the equilibrium constant has the units $(\text{bar})^n$. Then n is

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4. ΔG° for the reaction, $N_2 + 3H_2 \rightarrow 2NH_3$ is $-33kJ$. The K_p (in atm^{-2}) for the reaction was found to be'

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5. At $540K$, 0.10 mole of PCl_5 are heated in a 8 litre flask. The pressure of the equilibrium mixture is found to be 1.0 atm. The value of K_p (in atm) for the reaction is

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