CHEMISTRY

BOOKS - P BAHADUR CHEMISTRY (HINGLISH)

CHEMICAL EQUILIBRIUM

Exercise

1. Write equilibrium constant for the each :

(a) $N_2O_{4(g)} \Leftrightarrow 2NO_{2(g)}$

(b) $KClO_{3(g)} \Leftrightarrow KCl_s + (3/2)O_{2(g)}$

(c) $CaC_{2(s)} + 5O_{2(g)} \Leftrightarrow 2CaCO_{3(s)} + 2CO_{2(s)}$

(d) $N_{2(g)} + 3H_{2(g)} \Leftrightarrow 2NH_{3(g)}$

(e) $Fe^{3+}_{aq} + SCN^{-}_{aq} \Leftrightarrow Fe(SCN)^{2+}_{aq}$

(f) $CuSO_4.5H_2O_{(s)} \Leftrightarrow CuSO_{4(s)} + 5H_2O_{(v)}$

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2. The equilibrium constant expression for a gas reaction is :

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

Write the balanced chemical equation corresponding to this expression.

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3. The equilibrium constant of the reaction ,

$$SO_{3(g)} \Leftrightarrow SO_{2(g)} + \frac{1}{2}O_{2(g)},$$

is $0.20\text{mole}^{1/2}litre^{-1/2}$ at $1000K$. Calculate equilibrium constant for

$$2SO_{2(g)} + O_{2(g)} \Leftrightarrow 2SO_{3(g)}$$

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4. Calculate the equilibrium constant for the reaction,

$H_{2(g)} + CO_{2(g)} \Leftrightarrow H_2O_{(g)} + CO_{(g)}$ at $1395K$, if the

equilibrium constants at $1395K$ for the following are:

$2H_2O_{(g)} \Leftrightarrow 2H_2 + O_{2(g)}$ $(K_1 = 2.1 \times 10^{-13})$

$2CO_{2(g)} \Leftrightarrow 2CO_{(g)} + O_{2(g)}$ $(K_2 = 1.4 \times 10^{-12})$

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5. For the reactions, $N_{2(g)} + 3H_{2(g)} \Leftrightarrow 2NH_{3(g)}$. At $400K$, $K_p = 41 atm^{-2}$. Find the value of K_p for each of the following reactions at the same temperature:

(i) $2NH_{3(g)} \Leftrightarrow N_{2(g)} + 3H_{2(g)}$,

(ii) $\frac{1}{2}N_{2(g)} + \frac{3}{2}H_{2(g)} \Leftrightarrow NH_{3(g)}$,

(iii) $2N_{2(g)} + 6H_{2(g)} \Leftrightarrow 4NH_{3(g)}$

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6. Find out the value of K_c for each of the following equilibrium from the value of K_p:

(a) $2NOCl_{(g)} \Leftrightarrow 2NO_{(g)} + Cl_{2(g)}$,

$(K_p = 1.8 \times 10^{-2} atm$ at $500K)$

(*b*) $CaCO_{3(s)} \Leftrightarrow CaO_{(s)} + CO_{2(g)}$,

($K_p = 167atm$ at $1073K$)

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7. The rate of reversible reaction (change in concentration per second):

$PrCl_4^{2-} + H_2O \Leftrightarrow Pt(H_2O)Cl_3^- + Cl^-$,

was observed at $0.3ionic$ strength at $25^\circ C$ and noticed that

$$\frac{\Delta[PtCl_4^{2-}]}{\Delta t} = 3.9 \times 10^{-5}[PtCl_4^{2-}] - 2.1 \times 10^{-3}[Pt(H_2O)Cl_3^-][Cl^-]$$

Calculate: (a) Rate constant for forward and backward reaction.

(b) The equilibrium constant for the complexation of fourth Cl^- at $0.3ionic$ strength.

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8. Write a stoichiometric equation for the reaction between A_2 and C whose mechanism is given below. Determine the value of equilibrium constant for the first step. Write a rate law equation for the over all reaction in terms of its initial reactants.

$(i)\ A_2 \underset{K_2}{\overset{K_1}{\Longleftrightarrow}} 2A$

$K_1 = 10^{10} s^{-1}$ and $K_2 = 10^{10} M^{-1} s^{-1}$

$(ii)\ A + C \rightarrow AC$

$K = 10^{-4} M^{-1} S^{-1}$

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9. In which case does the reaction go farthest to completion: $K = 1K$, $K = 10^{10}$, $K = 10^{-10}$ and why?

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10. The equilibrium constant K_c for $A_{(g)} \Leftrightarrow B_{(g)}$ is 1.1. Which gas has a molar concentration greater than 1 ?

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11. Calculate the value of equilibrium constant K_p for the reaction:

$O_{2(g)} + O_{(g)} \Leftrightarrow O_{3(g)}$ ...(i)

if $NO_{2(g)} \Leftrightarrow NO_{(g)} + O_{(g)}$,

$K_{P_1} = 6.8 \times 10^{-49}$ ...(ii)

and $O_{3(g)} + NO_{(g)} \Leftrightarrow NO_{2(g)} + O_{2(g)}$,

$K_{P_2} = 5.8 \times 10^{-34}$....$(iii)$

If initial pressure of an equimolar mixture of the reactants in change (i) is 4.0^{-}, what are the equilibrium parital pressure of the reactants and products?

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12. Equilibrium constant, K_c for the reaction,

$N_{2(g)} + 3H_{2(g)} \Leftrightarrow 2NH_{3(g)}$,

at $500K$ is $0.061litre^2\text{mole}^{-2}$. At a particular time, the analysis shows that composition of the reaction mixture is $3.00mollitre^{-1}N_2$, $2.00mollitre^{-1}H_2$, and $0.500mollitre^{-1}NH_3$. Is the reaction at equilibrium? If not, in which direction does the reaction tend to proceed to reach equilibrium?

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13. The ester , ethyl acetate is formed by the reaction of ethanol and acetic acid and the equilibrium is represented as :

$CH_3COOH(l) + C_2H_5OH(l) \Leftrightarrow CH_3COOC_2H_5(l) + H_2O(l)$

(i) Write the concentration ratio (concentration quotient) Q for this reaction. Note that water is not in excess and is not a solvent in this reaction.

(ii) At 293 K, if one starts with 1.000 mol of acetic acid 0.180 mol of ethanol, there is 0.171 mol of ethyl acetate in the final equilibrium mixture . Calculate the equilibrium constant.

(iii) Starting with 0.50 mol of ethanol and 1.000 mol of acetic acid and maintaining it at 293 K, 0.214 mol of ethyl acetate is found after some time. Has equilibrium been reached?

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14. Consider the following equations for cell reaction:

$A + B \Leftrightarrow C + D$ ....(1)

and $2A + B \Leftrightarrow 2C + 2D$ ...(2)

How are E°_{cell} for equations (1) and (2) are related? What is relation between two equilibrium constants?

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15. For the gasesous reaction, $2NO_2 \Leftrightarrow N_2O_4$, calculate ΔG° and K_p for the reaction at $25^\circ C$. Given $G^\circ_{fN_2O_4}$ and $G^\circ_{fNO_2}$ are 97.82 and $51.30 kJ$ respectively. Also calculate ΔG^0 and K_p for reverse reaction.

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16. ΔG° for $\frac{1}{2}N_2 + \frac{3}{2}H_2 \Leftrightarrow NH_3$ is $-16.5 kJ mol^{-1}$ at $25^\circ C$. Find out K_p for the reaction. Also report K_p and ΔG° for:

$N_2 + 3H_2 \Leftrightarrow 2NH_3$ at $25^\circ C$

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17. Calculate the values of ΔE° and ΔH° for the reaction:

$2A_{(g)} + B_{(g)} \Leftrightarrow A_2B_{(g)}$

for which $K_p = 1.0 \times 10^{-10} atm^{-2}$ and $\Delta S = 5JK^{-1}$ and $T = 300K$.

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18. For the reaction at $298K$:

$A_{(g)} + B_{(g)} \Leftrightarrow D_{(g)} + C_{(g)}$

$\Delta H^{\circ} = 29.8kcal$ and $\Delta S^{\circ} = 100calK^{-1}$. Calculate the value of equilibrium constant.

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19. Calculate the value of equilibrium constant for the reaction:

$A_{(g)} + B_{(g)} \Leftrightarrow C_{(g)} + D_{(g)} + E_{(g)}$ at $300K$ and constant pressure.

All the reactants and products obey ideal gas nature. Given $\Delta U^{\circ} = -90.0 kcal, \Delta S^{\circ} = 100 cal K^{-1}$.

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20. Calculate the pressure for CO_2 at equilibrium if $\Delta G^{\circ} = 31.1 kcal$ at $300K$ for

$CaCO_{3(s)} \Leftrightarrow CaO_{(s)} + CO_{2(g)}$

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21. If a mixture of 3 moles of H_2 and one mole of N_2 is completely converted into NH_3. What would be the ratio of the initial and final volume at same temperature and pressure ?

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

$2NO_{(g)} + Br_{2(g)} \Leftrightarrow 2NOBr_{(g)}$.

When 0.087mole of NO and 0.0437mole of Br_2 are mixed in a closed container at constant temperature, 0.0518mole of $NOBr$ is obtained at equilibrium. Calculate equilibrium amount of nitric oxide and bromine.

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23. At $700K$ equilibrium constant for the reaction, $H_{2(g)} + I_{2(g)} \Leftrightarrow 2HI_{(g)}$

is 54.8. If $0.5 mollitre^{-1}$ of $HI_{(g)}$ is present at equilibrium at $700K$, what are the concentrations of $H_{2(g)}$ and $I_{2(g)}$, assuming that we initially started with $HI_{(g)}$ and allowed it to reach equilibrium at $700K$.

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24. Bromine monochloride, $(BrCl)$ decomposes into bromine and chlorine and reaches the equilibrium.

$2BrCl_{(g)} \Leftrightarrow Br_{2(g)} + Cl_{2(g)}$

For which $K_c = 32$ at $500K$. If initially pure $BrCl$ is present at a concentration of $3.30 \times 10^{-3} mollitre^{-1}$, what is its molar concentration in the mixture at equilibrium?

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25. $60 mL$ of H_2 and 42 mL of I_2 are heated in a closed vessel. At equilibrium, the vessel contains $28 mLHI$. Calculate degree of dissociation of HI.

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26. For a reaction $2HI \Leftrightarrow H_2 + I_2$, at equilibrium $7.8g, 203.2g$, and $1638.4g$ of H_2, I_2, and HI, respectively were found. Calculate K_c.

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27. In the dissociation of HI, 20% of HI is dissociated at equilibrium. Calculate K_p for

$HI(g) \Leftrightarrow 1/2H_2(g) + 1/2I_2(g)$

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28. At a certain temperature and a total pressure of $10^5 Pa$, iodine vapour contains 40% by volume of $I\text{atoms}$, Calculate K_p for the equilibrium.

$I_{2(g)} \Leftrightarrow 2I_{(g)}$

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29. Reaction between nitrogen and oxygen takes place as following:

$2N_{2(g)} + O_2 \Leftrightarrow 2N_2O_{(g)}$

If a mixture of $0.482\text{mole}N_2$ and 0.933mole of O_2 is placed in a reaction vessel of volume $10litre$ and allowed to form N_2O at a temperature for which $K_c = 2.0 \times 10^{-37} litremol^{-1}$. Determine the composition of equilibrium mixture.

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30. One mole of H_2 and one mole of CO are taken in a $10 litre$ vessel and heated to $725K$. At equilibrium, $40 percent$ of water (by mass) reacts with carbon monoxide according to the equation,

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

Calculate the equilibrium constant for the reaction.

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31. A sample of pure PCl_5 was introduced into an evacuated vessel at $473K$. After equilibrium was attained,concentration of PCl_5 was found to be $0.5 \times 10^{-1} mollitre^{-1}$. If value of K_c is $8.3 \times 10^{-3} mollitre^{-1}$. What are the concentrations of PCl_3 and Cl_2 at equilibrium ?

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32. The equilibrium constant for the following reactions is 1.6×10^5 at $1024K$,

$H_{2(g)} + Br_{2(g)} \Leftrightarrow 2HBr_{(g)}$

Find the equilibrium pressure of all gases, if 10.0^- of HBr is introduced into a sealed container at $1024K$.

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33. For the reaction is equilibrium :

$2NOBr_{(g)} \Leftrightarrow 2NO_{(g)} + Br_{2(g)}$

If P_{Br_2} is $\frac{P}{9}$ at equilibrium and P is total pressure, prove that $\frac{K_p}{P}$ is equal to $\frac{1}{81}$.

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34. K_c for $CO(g) + H_2O(g) \Leftrightarrow CO_2(g) + H_2(g)$ at $986^\circ C$ is 0.63. A mixture of 1 mol $H_2O(g)$ and 3 mol $CO_2(g)$ is allowed to react to come to an equilibrium. The equilibrium pressure is 2.0 atm.

a. Hoe many moles of H_2 are present at equilibrium ?

b. Calculate partial pressure of each gas at equilibrium.

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35. When C_2H_5OH and CH_3COOH are mixed in equivalent proportion, equilibrium is reached when $2/3$ of acid and alcohol are used. How much ester will be present when $2g$ "mole"cule of acid were to react with $2g$ "mole"cule of alcohol.

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36. When $\alpha - D$ glucose is dissolved in water, it undergoes a partial converion to $\beta - D$ glucose to exhibit mutarotation. This conversion stops when 63.6% of glucose is in β form. Assuming that equilibrium has been attained, calculate K_c for mutarotation.

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37. At $1127K$ and $1atm$ pressure, a gaseous mixture of CO and CO_2 in equilibrium with solid carbon has $90.55\,\%\,CO$ by mass:

$C_{(s)} + CO_{2(s)} \Leftrightarrow 2CO_{(g)}$

Calculate K_c for the reaction at the above temperature.

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

$FeO(s) + CO(g) \Leftrightarrow Fe(s) + CO_2(g), K_c = 5.0$

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39. Calculate the value of K_p and K_c at $25^{\circ}C$ for $H_2O_{(l)} \Leftrightarrow H_2O_{(v)}$. Given that aqueous tension of water at $25^{\circ}C$ is $0.0313atm$.

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40. $100g$ of $NaCl$ is stirred in $100mL$ of water at $20^\circ C$ till the equilibrium is attained:

(a) How much $NaCl$ goes into the solution and how much of it is left undissolved at equilibrium? The solubility of $NaCl$ at $20^\circ C$ is $6.15mol/litre$.

(b) What will be the amount of $NaCl$ left undissolved, if the solution is diluted to $200mL$?

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41. The vapour density of N_2O_4 at a certain temperature is 30. Calculate the percentage dissociation of N_2O_4 this temperature.

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42. Which of the following reaction will get affected by increase of pressure? Also mention, whether change will cause the reaction to go into the right or left direction?

(i) $CH_{4(g)} + 2S_{2(g)} \Leftrightarrow CS_{2(g)} + 2H_2S_{(g)}$

(ii) $CO_{2(g)} + C_{(s)} \Leftrightarrow 2CO_{(g)}$

(iii) $4NH_{3(g)} + 5O_{2(g)} \Leftrightarrow 4NO_{(g)} + 6H_2O_{(g)}$

(iv) $C_2H_{4(g)} + H_{2(g)} \Leftrightarrow C_2H_{6(g)}$

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43. Derive the best conditions for the formation of NH_3. Given,

$2NH_3 \Leftrightarrow N_2 + 3H_2, (\Delta H = +91.94kJ)$

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45. K_c for the reaction, $A+B \Leftrightarrow P+Q$ is 2.0×10^{-2} at $25^\circ C$ and it is 2.0×10^{-1} at $50^\circ C$. Predict whether the forward reaction is exothermic or endothermic.

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46. In a gases reaction, $A_{(g)}+B_{(g)} \Leftrightarrow C_{(g)}$, predict the effect of addition of inert gas, if addition is made at : (a) constant volume, (b) constant pressure.

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47. In a gaseous reaction, $A_{(g)}+B_{(g)} \Leftrightarrow C_{(g)}+D_{(g)}$, the increase in temperature causes the change in the concentrations of A, B, C and D. The concentrations of C and D also change on addition of some amount of A. Does the value of K change in either of the two situations?

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

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

with degree of dissociation α, which is small compared with unity. The expression for K_p in terms of α and the total pressure P_T is

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49. The K_c for $A_{2(g)} + B_{2(g)} \Leftrightarrow 2AB_{(g)}$ at $100^\circ C$ is 50. If one litre flasks containing one mole of A_2 is connected with a two litre flask containing 2mole of B_2, how many mole of AB will be formed at $100^\circ C$?

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50. The K_p values for the reaction, $H_2 + I_2 \Leftrightarrow 2HI$, at $460^\circ C$ is 49. If the initial pressure of H_2 and I_2 is $0.5atm$ respectively, determine the partial pressure of each gas at equilibrium.

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51. One mole of H_2 two moles of I_2 and three moles of HI are injected in one litre flask. What will be the concentration of H_2, I_2 and HI at equilibrium at $500^\circ C$. K_c for reaction $H_2 + I_2 \Leftrightarrow 2HI$ is 45.9.

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52. $0.5mol$ of H_2 and 0.5 mol of I_2 react in $10L$ flask at $448^\circ C$. The equilibrium constant (K_c) is 50 for

$H_2 + I_2 \Leftrightarrow 2HI$

a. What is the value of K_p?

b. Calculate the moles of I_2 at equilibrium.

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53. K_c for $CO(g) + H_2O(g) \Leftrightarrow CO_2(g) + H_2(g)$ at $986^\circ C$ is 0.63. A mixture of 1 mol $H_2O(g)$ and 3 mol $CO_2(g)$ is allowed to react to come to an equilibrium. The equilibrium pressure is 2.0 atm.

a. Hoe many moles of H_2 are present at equilibrium ?

b. Calculate partial pressure of each gas at equilibrium.

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54. A sample of air consisting of N_2 and O_2 was heated to $2500K$ until the equilibrium

$N_2(g) + O_2(g) \Leftrightarrow 2NO(g)$

was established with an equlibrium constant, $K_c = 2.1 \times 10^{-3}$. At equilibrium, the $\text{mole}\%$ of NO was 1.8. Eatimate the initial composition of air in mole fraction of N_2 and O_2.

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55. At $700K$, CO_2 and H_2 react to form CO and H_2O. For this purpose, K_c is 0.11. If a mixture of 0.45 mol of CO_2 and 0.45 mol of H_2 is heated to $700K$.

(a) Find out amount of each gas at equilibrium.

(b) When equilibrium has been reached, another 0.34 mol of CO_2 and 0.34 mol of H_2 are added to the reaction mixture. Find the composition of of mixture at new equilibrium.

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56. A mixture of SO_3, SO_2 and O_2 gases is maintained in a $10L$ flask at a temperature at which the equilibrium constant for the reaction is 100:

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

a. If the number of moles of SO_2 and SO_3 in the flask are equal. How many moles of O_2 are present?

b. If the number of moles of SO_3 in flask is twice the number of moles of SO_2, how many moles of oxygen are present?

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57. The K_p for the reaction $N_2O_4 \Leftrightarrow 2NO_2$ is $640mm$ at $775K$. Calculate the percentage dissociation of N_2O_4 at equilibrium pressure of $160mm$. At what pressure, the dissociation will be 50% ?

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58. An equilibrium mixture at $300K$ contains N_2O_4 and NO_2 at 0.28 and $1.1atm$, respectively. If the volume of container is doubles, calculate the new equilibrium pressure of two gases.

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59. At $540K, 0.10mol$ of PCl_5 is heated in a $8L$ flask. The pressure of equilibrium mixture is found to be $1.0atm$. Calculate K_p and K_c for the reaction.

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60. At some temperature and under a pressure of 4 atm, PCl_5 is 10% dissociated. Calculated the pressure at which PCl_5 will be 20% dissociated temperature remaining same.

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61. The degree of dissociation is 0.4 at $400K$ and 1.0 atm for the gaseous reaction

$PCl_5 \Leftrightarrow PCl_3 + Cl_2$

assuming ideal behaviour of all gases, calculate the density of equilibrium mixture at $400K$ and 1.0 atm (relative atomic mass of P is 31.0 and of Cl is 35.5).

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62. NH_3 is heated at 15 at, from $25^\circ C$ to $347^\circ C$ assuming volume constant. The new pressure becomes 50 atm at equilibrium of the reaction $2NH_3 \Leftrightarrow N_2 + 3H_2$. Calculate $\%$ moles of NH_3 actually decomposed.

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63. Calculate the value of $\log K_p$ for the reaction, $N_{2(g)} + 3H_{2(g)} \Leftrightarrow 2NH_{3(g)}$ at $25^\circ C$. The standard enthalpy of formation of $NH_{3(g)}$ is $-46kJ$ and standard entropies of $N_{2(g)}$, $H_{2(g)}$ and $NH_{3(g)}$ are 191, 130, 192 $JK^{-1}mol^{-1}$. respectively. ($R = 8.3JK^{-1}mol^{-1}$)

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64. Calculate the percent dissociation of $H_2S(g)$ if $0.1mol$ of H_2S is kept in $0.4L$ vessel at $1000K$. For the reaction:

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

The value of K_c is 1.0×10^{-6}

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65. When S in the form of S_8 is heated at $900K$, the initial pressure of $1atm$ falls by 29% at equilibrium. This is because of conversion of some S_8 to S_2. Find the K_p for reaction.

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66. When $3.06g$ of solid NH_4HS is introduced into a two-litre evacuated flask at $27^\circ C, 30\%$ of the solid decomposes into gaseous ammonia and hydrogen sulphide. (i) Calculate K_c and K_p for the reaction at $27^\circ C$. (ii) What would happen to the equilibrium when more solid NH_4HS is introduced into the flask?

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67. A vessel at $1000K$ contains carbon dioxide with a pressure of $0.5atm$. Some of the carbon dioxide is converted to carbon monoxide on addition of graphite. Calculate the value of K_p if total pressure at equilibrium is $0.8atm$.

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68. At $817^{\circ}C$, K_p for the reaction between $CO_{2(g)}$ and excess hot graphite (s) is $10atm$.

(a) What are the equilibrium concentration of the gases at $817^{\circ}C$ and a total pressure of $5atm$?

(b) At what total pressure, the gas contains $5\%\,CO_2$ by volume?

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69. The equilibrium constant K_p of the reaction: $2SO_2 + O_2 \Leftrightarrow 2SO_3$ is $900atm^{-1}$ at $800K$. A mixture constaining SO_3 and O_2 having initial pressure of 1 atm and 2 atm respectively, is heated at constant volume to equilibriate. Calculate the partial pressure of each gas at $800K$ at equilibrium.

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70. For the reaction

$CO(g) + 2H_2(g) \Leftrightarrow CH_3OH(g)$

Hydrogen gas is introduced into a five-litre flask at $327^{\circ} C$, containing 0.2 mol of $CO(g)$ and a catalyst, untill the pressure is $4.92 atm$. At this point, 0.1 mol of $CH_3OH(g)$ is formed. Calculate the equilibrium constants K_p and K_c.

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71. When 0.15 mol of CO taken in a $2.5 L$ flask is maintained at $750 K$ along with a catalyst, the following reaction takes place

$CO(g) + 2H_2(g) \Leftrightarrow CH_3OH(g)$

Hydrogen is introduced until the total pressure of the system is 8.5 atm at equilibrium and 0.08 mol of methanol is formed.

Calculate

a. K_p and K_c

b. The final pressure, if the same amount of CO and H_2 as before are used, but with no catalyst so that the reaction does not take place.

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72. For the reaction

$Ag(CN)_2^{\ominus} \Leftrightarrow Ag^{\oplus} + 2CN^{\ominus}$, the K_c at $25^{\circ}C$ is 4×10^{-19} Calculate $[Ag^{\oplus}]$ in solution which was originally $0.1M$ in KCN and $0.03M$ in $AgNO_3$.

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73. The value of K_p is $1 \times 10^{-3} atm^{-1}$ at $25^{\circ}C$ for the reaction: $2NO + Cl_2 \Leftrightarrow 2NOCl$. A flask contains NO at $0.02atm$ and at $25^{\circ}C$. Calculate the mole of Cl_2 that must be added if 1% of the NO is to be converted to $NOCl$ at equilibrium. The volume of the flask is such that $0.2mole$ of gas produce $1atm$ pressure at $25^{\circ}C$. (Ignore probable association of NO to N_2O_2.)

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74. When 1pentyne (A) is treated with $4N$ alcoholic KOH at $175^{\circ}C$, it is slowly converted into an equilibrium mixture of 1.3% of 1pentyne (A), 95.2% 2-pentyne (B) and 3.5% of $1, 2$-pentandiene (C). The equilibrium was maintained at $175^{\circ} C$. calculate ΔG^{Θ} for the following equilibria:

$B \Leftrightarrow A, \Delta G^{\Theta}_1 = ?$

$B \Leftrightarrow C, \Delta G^{\Theta}_2 = ?$

From the calculated value of ΔG^{Θ}_1 and ΔG^{Θ}_2, indicate the order of stability of A, B and C.

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

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76. For the equilibrium, $N_2O_4 \Leftrightarrow 2NO_2$, $\left(G^{\circ}_{N_2O_4}\right)_{298} = 100 kJ / mol$ and $\left(G^{\circ}_{NO_2}\right)_{298} = 50 kJ / mol$.

(a) When $5mo\frac{l}{l}itre$ of each is taken, calculate the value of ΔG for the reaction at $298K$.

(b) Find the direction of reaction.

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77. Calculate the equilibrium constant for the reaction

$H_2(g) + CO_2(g) \Leftrightarrow H_2O(g) + CO(g)$ at $1395K$

If the equilibrium constants at $1395K$ for the following are:

$2H_2O(g) \Leftrightarrow 2H_2 + O_2(g), K_1 = 2.1 \times 10^{-13}$

$2CO_2(g) \Leftrightarrow 2CO(g) + O_2(g), K_2 = 1.4 \times 10^{-12}$

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78. The equilibrium constant K_c for $A(g) \Leftrightarrow B(g)$ is 1.1. Which gas has a molar concentration greater than 1.

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79. For the reaction $A + B \Leftrightarrow 3. C$ at $25^{\circ} C$, a $3L$ vessel contains 1, 2, and 4 moles of A, B and C respectively. Predict the direction of reaction if:

a. K_c for the reaction is $10.$

b. K_c for the reaction is $15.$

c. K_c for the reaction is 10.66

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80. The activation energy of $H_2 + I_2 \Leftrightarrow 2HI(g)$ in equilibrium for the forward reaction is $167kJmol^{-1}$ whereas for the reverse reaction is $180kJmol^{-1}$. The presence of catalyst lowers the activation energy by $80kJmol^{-1}$. Assuming that the reactions are made at $27^{\circ} C$ and the frequency factor for forwatd and backward reactions are 4×10^{-4} and 2×10^{-3} respectively, calculate K_c.

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81. For a gaseous phase reaction $A + 2B \Leftrightarrow AB_2$, $K_c = 0.3475 L^2 \text{mole}^{-2}$ at $200^\circ C$. When 2 moles of B are mixed with one "mole" of A, what total pressure is required to convert 60% of A in AB_2?

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82. $0.96g$ of HI were heated to attain equilibrium $2HI \Leftrightarrow H_2 + I_2$. The reaction mixture on titration requires $15.7mL$ of $N/10$ hypo solution. Calculate degree of dissociation of HI.

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83. The degree of dissociation of HI at a particualr temperature is 0.8. Calculate the volume of $2MNa_2S_2O_3$ solution required to neutralise the iodine present in an equilibrium mixture of a reaction when 2 mol each of H_2 and I_2 are heated in a closed vessel of $2L$ capacity and the equilibrium mixture is freezed.

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84. At $340K$ and 1 atm pressure, N_2O_4 is 66% into NO_2. What volume of $10gN_2O_4$ ocuupy under these conditions?

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85. N_2O_4 dissociates as $N_2O_4 \Leftrightarrow 2NO_2$. At $55^\circ C$ and one atmospehere, $\%$ decomposition of N_2O_4 is 50.3%. At what P and same temperature, the equilibrium mixture will have the ratio of $N_2O_4 : NO_2$ as $1:8$?

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86. At $273K$ and 1 atm ,a moles of N_2O_4 decomposes to NO_2 according to equation $N_2O_4(g) \Leftrightarrow 2NO_2(g)$. To what extent has the decomposition proceeded when the original volume is 25% less than that of exisiting volume?

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87. A mixture of one mole of CO_2 and "mole" of H_2 attains equilibrium at a temperature of $250^{\circ} C$ and a total pressure of 0.1 atm for the change $CO_2(g) + H_2(g) \Leftrightarrow CO(g) + H_2O(g)$. Calculate K_p if the analysis of final reaction mixture shows 0.16 volume percent of CO.

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88. For the equilibrium:

$CO_{(g)} + H_2O_{(g)} \Leftrightarrow CO_{2(g)} + H_{2(g)}$ the standard enthalpy and entropy changes at $300K$ and $1200K$ for the forward reaction are as follows:

$$\left(\Delta H^{\circ}_{300K} = -41.16kJmol^{-1},\right), \left(\Delta S^{\circ}_{300K} = -0.0424kJmol^{-1}\right), \left(\Delta H^{\circ}_{120$$

In which direction will the reaction be spontaneous?

(a) At $300K$,

(b) At $1200K$, when at equilibrium $P_{CO} = P_{CO_2} = P_{H_2} = P_{H_2O} = 1atm$

Also calculate K_p for the reaction at each temperature.

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89. The equilibrium mixture for

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

present in $1L$ vessel at $600^\circ C$ contains $0.50, 0.12,$ and 5.0 moles of SO_2, O_2, and SO_3 respectively.

a. Calculate K_c for the given change at $600^\circ C$.

b. Also calculate K_p.

c. How many moles of O_2 must be forced into the equilibrium vessel at $600^\circ C$ in order to increase the concentration of SO_3 to 5.2 mol?

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90. At $627^\circ C$ and 1 atm SO_3 is partially dissociated into SO_2 and O_2 by the reaction

$SO_3(g) \Leftrightarrow SO_2(g) + 1/2O_2(g)$

The density of the equilibrium mixture is $0.925gL^{-1}$. What is the degree of dissociation?

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91. N_2O_4 is 25% dissociated at $37^\circ C$ and 1 atm pressure. Calculate

a. K_p

b. The percentage dissociation at 0.1 atm and $37^\circ C$.

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92. In a mixture of N_2 and H_2 in the ratio $1:3$ at $30atm$ and $300^\circ C$, the $\%$ of NH_3 at equilibrium is 17.8. Calculate K_p for $N_2 + 3H_2 \Leftrightarrow 2NH_3$.

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93. The equilibrium concentraion of the reactants and products for the given equilibrium in a two litre container are shown below:

$$\underset{2M}{PCl_{3(g)}} + \underset{1M}{Cl_{2(g)}} \Leftrightarrow \underset{4M}{PCl_{5(g)}}$$

(i) If 2 mole of Cl_2 are added in the container, find the new equilibrium concentration of each.

(ii) If the equilibrium mixture reported initially is transferred into $4litre$ vessel, what would be the new concentration at equilibrium?

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94. 1mol of Cl_2 and 3 mol of PCl_5 are placed in a $100L$ vessel heated to $227^\circ C$. The equilibrium pressure is 2.05 atm. Assuming ideal behaviour, calculate the degree of dissociation for PCl_5 and K_p for the reaction.

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

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95. A mixture of 2 moles of CH_4 and $34g$ of H_2S was placed in an evacuated chamber, which was then heated to an maintained at $727^\circ C$. When equilibrium was established in the gaseous phase reaction: $CH_4 + 2H_2S \Leftrightarrow CS_2 + 4H_2$, the total pressure in the container was $0.92atm$ and the partial pressure of hydrogen was $0.2atm$. Calculate the volume of container.

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96. A graph plotted between $\log_{10} K_c$ and $1/T$ is straight line with intercept 10 and slpoe equal t0 $0.5.$ Calculate :

(i) pre -exponential factor A.

(ii) heat of reaction at $298K$.

(iii) equilibrium constant at $298K$.

(iv) equilibrium constant in at $800k$ assuming ΔH remains constant in between $298K$ and $800K$.

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97. K_p for the reaction, $N_2 + 3H_2 \Leftrightarrow 2NH_3$ is $1.6 \times 10^{-4} atm^{-2}$ at $400^\circ C$. What will be K_p at $500^\circ C$? Heat of reaction in this temperature range is $-25.14kcal$.

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98. ΔG° for $\frac{1}{2}N_2 + \frac{3}{2}H_2 \Leftrightarrow NH_3$ is $-16.5kJmol^{-1}$. Find out K_p for the reaction. Also report K_p and ΔG° for : $N_2 + 3H_2 \Leftrightarrow 2NH_3$ at $25^{\circ}C$.

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99. For gasesous reaction $A + B \Leftrightarrow C$, the equilibrium concentration of A and B at a temperature are $15mollitre^{-1}$. When volume is doubled the reaction has equilibrium concentration of A as $10mollitre^{-1}$. Calculate:

(i) K_c

(ii) Concentration of C in originl equilibrium.

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100. K_p for the reaction $N_2 + 3H_2 \Leftrightarrow 2NH_3$ at $400^{\circ}C$ is 1.64×10^{-4}. Find K_c. Also find $\Delta G^{\ominus}$ using K_p and K_c values and interpret the difference.

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101. Equilibrium constant (K_p) for $2H_2S_{(g)} \Leftrightarrow 2H_{2(g)} + S_{2(g)}$ is $0.0118 atm$ at $1065^\circ C$ and heat of dissociation is $42.4 kcal$. Find equilibrium constant at $1132^\circ C$.

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102. H_2 and I_2 are mixed at $400^\circ C$ in a $1.0L$ container, and when equilibrium is established, the following concentrations are present: $[HI] = 0.8M$, $[H_2] = 0.08M$, and $[I_2] = 0.08M$. If now an additional 0.4 mol of HI is added, what are the new equilibrium concentrations, when the new equilibrium $H_2(g) + I_2(g) \Leftrightarrow 2HI(g)$ is re-established?

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103. $0.0755g$ of selenium vapours occupying a volume of $114.2mL$ at $700^\circ C$ and $185mm$ of Hg. The vapours are in equilibrium as:

$Se_{6(g)} \Leftrightarrow 3Se_{2(g)}$

Calculate:

(i) Degree of dissociation of Se,

(ii) K_p,

(iii) K_c.

Atomic weight of Se is 79.

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104. $COG_{2(g)}$ in presence of catalyst at $1000^\circ C$ shows the equilibrium:

$2COF_{2(g)} \Leftrightarrow CO_{2(g)} + CF_{4(g)}$

At equilibrium $500mL$ of the equilibrium mixture at STP contains $300mL$ of (COF_2 and CO_2) at STP. If total pressure is $10atm$, calculate K_p.

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105. For $NH_4HS(s) \Leftrightarrow NH_3(g) + H_2S(g)$, the observed, pressure for reaction mixture in equilibrium is 1.12 atm at $106^\circ C$. What is the value of

K_p for the reaction?

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106. When $20g$ of $CaCO_3$ were put into $10litre$ flask and heated to $800^\circ C$, 35% of $CaCO_3$ remained unreacted at equilibrium. K_p for decomposition of $CaCO_3$ is :

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107. Some acid NH_4HS is placed in flask containing $0.5atm$ of NH_3. What would be pressures of NH_3 and H_2S when equilibrium is reached?

$NH_4HS_{(s)} \Leftrightarrow NH_{3(g)} + H_2S_{(g)}, K_p = 0.11$

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108. To the system,

$LaCl_3(s) + H_2O(g) \Leftrightarrow LaClO(s) + 2HCL(g) - \text{Heat}$ already at equilibrium, more water vapour is added without altering temperature or volume of the system. When equilibrium is re-established, the pressure of water vapour is doubled. The pressure of HCl present in the system increases by a factor of

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109. At a certain temperature , K_p for dissociation of solid $CaCO_3$ is 4×10^{-2} atm and for the reaction, $C(s) + CO_2 \Leftrightarrow 2CO$ is 2.0 atm, respectively. Calculate the pressure of CO at this temperature when solid $C, CaO, CaCO_3$ are mixed and allowed to attain equilibrium.

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110. Solid Ammonium carbamate dissociates as:

$NH_2COONH_4(s) \Leftrightarrow 2NH_3(g) + CO_2(g)$.

In a closed vessel, solid ammonium carbonate is in equilibrium with its dissociation products. At equilibrium, ammonia is added such that the partial pressure of NH_3 at new equilibrium now equals the original total pressure. Calculate the ratio of total pressure at new equilibrium to that of original total pressure. Also find the partial pressure of ammonia gas added.

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111. In the preparation of CaO from $CaCO_3$ using the equilibrium,

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

K_p is expressed as

$$\log K_p = 7.282 - \frac{8500}{T}$$

For complete decomposition of $CaCO_3$, the temperature in celsius to be used is:

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112. A vessel of $2.50 litre$ was filled with 0.01 mole of Sb_2S_3 and 0.01 mole of H_2 to attain the equilibrium at $440^\circ C$ as:

$Sb_2S_{3(s)} + 3H_{2(g)} \Leftrightarrow 2Sb_{(s)} + 3H_2S_{(g)}$

After equilibrium the H_2S formed was analysed by dissolving it in water and treating with excess of Pb^{2+} to give $1.029g$ of PbS as precipitate. What is value of K_c of the reaction at $440^\circ C$? (At weight of $Pb = 206$)

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113. 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 is 1.7 and 5.3 respectively. Calculate equilibrium constant for the formation of S_3^{2-} from S_2^{2-} and S.

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114. Calculate K_c for the reaction $KI + I_2 \Leftrightarrow KI_3$. Given that initial weight of KI is $1.326g$ weight of KI_3 is $0.105g$ and number of moles of free I_2 is 0.0025 at equilibrium the volume of solution is $1 - L$.

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115. To $500mL$ of $0.150MAgNO_3$ solution were added $500mL$ of $1.09MFe^{2+}$ solution and the reaction is allowed to reach an equilibrium at $25^\circ C$

$Ag^{\oplus}(aq) + Fe^{2+}(aq) \Leftrightarrow Fe^{3+}(aq) + Ag(s)$

For 25 mL of the solution, $30mL$ of $0.0832MKMnO_4$ was required for oxidation. Calculate the equilibrium constant for the the reaction $25^\circ C$.

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116. A saturated solution of iodine in water contain $0.330gI_2perlitre$. More than this I_2 can be dissolved in KI solution because of the following equilibrium.

$I_{2(g)} + I^- \Leftrightarrow I_3^-$

A $0.100MKI$ solution actually dissolves $12.5g\text{iodine per litre}$, most of which is converted to I_3^-. Assuming that the concentration of I_2 in all saturated solution is the same, calculate the equilibrium constant for the above reaction. What is the effect of adding water to a clear saturated solution of I_2 in the KI solution?

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117. For the equilibrium:

$LiCl.3NH_{3(s)} \Leftrightarrow LiCl.NH_{3(s)} + 2NH_3, K_p = 9atm^2$

at $40^\circ C$. A $5litre$ vessel contains 0.1 mole of $LiCl.NH_3$. How many mole of NH_3 should be added to the flask at this temperture to derive the backward reaction for completion?

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118. Consider the sublimation of mothballs at $27^\circ C$ in a vessel having dimensions $10 \times 10 \times 10m^3$. Assume that the mothballs are pure solid naphthalene (density $1.16g/cm^3$) and that they are spheres with a diameter $12.0mm$. The equilibrium constant (K_c) for the sublimation of napthalene $C_{10}H_{8(s)} \Leftrightarrow C_{10}H_{8(v)}$ is 5.40×10^{-6} at $27^\circ C$.

(a) When excess mothballs are present, how many gaseous naphthalene molecules are in the room at equilibrium

(b) How many mothballs are required to saturate the room with gaseous naphthalene?

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119. Would $1\%\,CO_2$ in air be sufficient to prevent any loss in weight when M_2CO_3 is heated at $120^\circ C$?

$M_2CO_3(s) \Leftrightarrow M_2O(s) + CO_2(g)$

$K_p = 0.0095$ atm at $120^\circ C$. How long would the partial pressure of CO_2 have to be to promote this reaction at $120^\circ C$?

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120. Under what pressure conditions $CuSO_4.5H_2O$ be efforescent at $25^\circ C$. How good a drying agent is $CuSO_4.3H_2O$ at the same temperature? Given

$CuSO_4.5H_2O(s) \Leftrightarrow CuSO_4.3H_2O(s) + 2H_2O(v)$

$K_p = 1.086 \times 10^{-4} atm^2$ at $25^\circ C$. Vapour pressure of water at $25^\circ C$ is 23.8 mm of Hg.

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121. For the reaction,

$2Fe^{3+}_{(aq.)} + Hg^{2+}_{(aq.)} \Leftrightarrow 2Fe^{2+}_{(aq.)} + 2Hg^{2+}_{(aq.)}$

$K_c = 9.14 \times 10^{-6}$ at $25^{\circ}C$. If the initial concentration of the ions are $Fe^{3+} = 0.5M$, $(Hg_2)^{2+} = 0.5M$, $Fe^{2+} = 0.03M$ and $Hg^{2+} = 0.03M$. What will be the concentrations of ions at equilibrium?

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122. When NO and NO_2 are mixed, the following equilibria are readily obtained,

$2NO_2 \Leftrightarrow N_2O_4, K_p = 6.8atm^{-1}$

$NO + NO_2 \Leftrightarrow N_2O_3$

In an experiment when NO and NO_2 are mixed in the ratio of $1:2$, the final total pressure was 5.05 atm and the partial pressure of N_2O_4 was 1.7 atm. Calculate

a. the equilibrium partial pressure of NO.

b. K_p for $NO + NO_2 \Leftrightarrow N_2O_3$.

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123. Two solid compounds A and B dissociate into gaseous products at $20^\circ C$ as

a. $A(s) \Leftrightarrow A'(s) + H_2S(g)$

b. $B(s) \Leftrightarrow B'(g) + H_2S(g)$

At $20^\circ C$ pressure over excess solid A is 50 mm and that over excess solid B is 68 mm. Find:

a. The dissociation constant of A and B

b. Relative number of moles of A' and B' in the vapour phase over a mixture of the solids A and B.

c. Show that the total pressure of gas over the solid mixture would be 84.4 mm.

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124. Solid NH_4I on rapid heating in a closed vessel at $357^\circ C$ dvelops a constant pressure of $275mmHg$ owing to partial decomposition of NH_4I into NH_3 and HI but the pressure gradually increases further (when the excess solid residue remains in the vessel) owing to the dissociation of HI. Calculate the final pressure developed at equilibrium. K_p for HI dissociation is 0.015 at $357^\circ C$.

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125. In a reaction at equilibrium, $'x'$ mole of reactant A decompose to give $1molar$ of C and D. It has been found that the fraction of A decomposed at equilibrium is independent of initial concentration of A. Calculate x.

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126. For a reaction, $aA + bB \Leftrightarrow cC + dD$, the reaction quotient $Q = \dfrac{[C]_0^c[D]_0^d}{[A]_0^a[B]_0^b}$, where $[A]_0$, $[B]_0$, $[C]_0$, $[D]_0$ are initial concentrations.

Also $K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$ where $[A]$, $[B]$, $[C]$, $[D]$ are equilibrium concentrations. The reaction proceeds in forward direction if $Q < K_c$ and in backward direction if $Q > K_c$. The variation of K_c with temperature is given by: $2303\frac{\log(K_{C_2})}{K_{C_1}} = \frac{\Delta H}{R}\left[\frac{T_2 - T_1}{T_1 T_2}\right]$.

For gaseous phase reactions $K_p = K_c(RT)^{\Delta n}$ where $\Delta n =$ moles of gaseous products $-$ moles of gaseous reactants. Also $-\Delta G^{\circ} = 2.303RT\log_{10}K_c$.

The heat or reaction for an endothermic reaction, in equilibrium is $1200 cal$, at constant volume is more than at constant pressure at $300K$.

The ratio of K_p / K_c is:

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127. N_2 and O_2 combine at a given temperature to produce NO. At equilibrium the yield of NO is 'x' precent by volume. If $x = \sqrt{Ka.b} - \frac{K(a+b)}{4}$, where K is the equilibrium constant of the given reaction at the given temperature and a and b are the volume percentage of N_2 and O_2, respectively, in the initial state. Report. Report the maximum value of K at which X is maximum

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128. The moisture content of a gas is often expressed in terms of the dew point. The point is the temperature to which the gas must be cooled before the gas becomes saturated with water vapour. At this temperture, water or ice (depending on the temperature) will be deposited on a solid surface. Dew point of H_2O is $-43^\circ C$ at which vapour pressure of ice formed is $0.07mm$. Assuming that the $CaCl_2$ owes its desicationg properties to the formation of $CaCl_2.2H_2O$, calculate :

(i) K_p at that temperature of the reaction,

(ii) ΔG°

$CaCl_{2(s)} + 2H_2O_{(g)} \Leftrightarrow CaCl_2.2H_2O_{(s)}$.

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129. Consider the equilibrium : $P_{(g)} + 2Q_{(g)} \Leftrightarrow R_{(g)}$. When the reaction is carried out at a certain temperature, the equilibrium concentration of P and Q are $3M$ and $4M$ respectively. When the volume of the vessel is doubled and the equilibrium is allowed to be re-established, the concentration of Q is found to be $3M$. Find:

$(a) K_c$

(b) Concentration of R at two equilibrium stages.

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130. (i) The equilibrium $H_{2(g)} + CO_{2(g)} \Leftrightarrow H_2O_{2(g)} + CO_{(g)}$ is established in an evacuated vessel at $723K$ starting with $0.1 mol$ of H_2 and 0.2 mole of CO_2. If the equilibrium mixture contains 10 mole per cent of water vapour, calculate K_p, given that the equilibrium pressure is $0.5 atm$. Calculate the partial pressures of the component species and the volume of the container.

(ii) If now, into the flask, solid CoO and solid Co are introduced two new equilibrium are established.

$CoO_{(s)} + H_{2(g)} \Leftrightarrow Co_{(s)} + H_2O_{(g)}$,

$CoO_{(s)} + CO_{(g)} \Leftrightarrow Co_{(g)} + CO_{2(g)}$

The new equilibrium mixture contains 30 mole per cent of water vapour. Calculate the equilibrium constants for the new equilibria.

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131. The equilibrium $p-\text{xyloquinone} + \text{methylene white} = p-\text{xylohydroquinone} + \text{methylen}$, may be studied convinently by observing the difference in colour methylene white and methylene blue. One milli- mole of methylene blue was added to 1 litre of solution that was $0.24M$ in $p-\text{xylohdroquinone}$ and $0.012M$ in $p-\text{xythloquinone}$. It was then found that 4% of the added methylene blue was reduced to methylene white. What is the equilibrium constant of the above reaction? The equation is balanced with one mole each of 4 substances.

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132. A certain gas A polymerizes to a small extent at a given temperature and pressure, $nA \Leftrightarrow A_n$. Show that the gas obeys the approx. equation $\frac{PV}{RT}=\left[1-\frac{(n-1)K_c}{V^{n-1}}\right]$, where $K_c=\frac{[A_n]}{[A]^n}$ and V is the volume of the container. Assume that initially one mole of A was taken in the container.

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133. A$100dm^3$ flask contains 10 mole each of N_2 and H_2 at $777K$. After equilibrium was reached, parital pressure of H_2 was $1atm$. At this point $5litre$ of $H_2O_{(l)}$ was injected and gas mixture was cooled to $298K$. Find out the pressure of gaseous mixture left.

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134. Calculate ΔG for the reaction at $25^\circ C$ when partial pressure of reactants H_2, CO_2, H_2O and CO are 10, 20, 0.02 and $0.01atm$ respectively.

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

Given G_f° for $H_{2(g)}$, $CO_{2(g)}$, $H_2O_{(g)}$ and $CO_{(g)}$ are 0, -394.37, -228.58, $-137.15KJ$ respectively.

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Objective problems

1. The equilibrium constant for a reacton

$N_2(g) + O_2(g) = 2NO(g)$ is 4×10^{-4} at $2000K$. In the presence of catalyst, the equilibrium constant is attained 10 times faster. The equilibrium constant in the presence of catalyst, at $2000K$ is

A. 4×10^{-3}

B. 4×10^{-4}

C. 4×10^{-5}

D. none of these

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2. For the decomposition reaction:

$NH_2COONH_{4(s)} \Leftrightarrow 2NH_{3(g)} + CO_{2(g)}$.

$(K_p = 2.9 \times 10^{-5} atm^2)$

The total pressure of gases at equilibrium when 1mole 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. $0.0766 atm$

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3. The partial pressure of $CH_3OH_{(g)}$, $CO_{(g)}$ and $H_{2(g)}$ in equilibrium mixture for the reaction, $CO_{(g)} + 2H_{2(g)} \Leftrightarrow CH_3OH_{(g)}$ are 2.0, 1.0

and 0.1 atm respectively at $427^\circ C$. The value of K_P for deomposition of CH_3OH to CO and H_2 is:

A. $10^2 atm$

B. $2 \times 10^2 atm^{-1}$

C. $50^2 atm^2$

D. $5 \times 10^{-3} atm^2$

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4. The equilibrium constant (K_p) at $27^\circ C$ for a homegenous gasesous reaction is 10^{-8}. The standard free energy change ΔG° for the reaction is: (Use $R = 2 cal K^{-1} mol^{-1}$)

A. $11.05 kcal$

B. $-1.8 kcal$

C. $-4.1454 kcal$

D. $+4.1454kcal$

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5. The equilibrium constant K for the reaction $2HI(g) \Leftrightarrow H_2(g) + I_2(g)$ at room temperature is 2.85 and that at $698K$ is 1.4×10^{-2}. This implies

A. HI is exothermic compound

B. HI is very stabel at room temperature

C. HI is realtively less stable than H_2 and I_2

D. HI is resonance stabilised

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6. Consider the reaction

$A(g) + B(g) \Leftrightarrow C(g) + D(g)$

Which occurs in one step. The specific rate constant are 0.25 and 5000 for the forward and reverse reaction, respectively. The equilibrium constant is

A. 2.0×10^{-4}

B. 4.0×10^{2}

C. 5.0×10^{-5}

D. 2.5×10^{-6}

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7. XY_2 dissociates $XY_2(g) \Leftrightarrow XY(g) + Y(g)$. When the initial pressure of XY_2 is 600 mm Hg, the total equilibrium pressure is 800 mm Hg. Calculate K for the reaction Assuming that the volume of the system remains unchanged.

A. 50

B. 100

C. 166.6

D. 400

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8. The equilibrium constant for a reaction $A+B \Leftrightarrow C+D$ is 1×10^{-2} at $298K$ and is 2 at $273K$. The chemical process resulting in the formation of C and D is

A. exothermic

B. endothermic

C. unpredictable

D. there is no relationship between K and ΔH

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9. In the dissociation of PCl_5 as

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

If the degree of dissociation is α at equilibrium pressure P, then the equilibrium constant for the reaction is

A. $K_p = \dfrac{\alpha^2}{1+\alpha^2 P}$

B. $K_p = \dfrac{\alpha^2 P^2}{1-\alpha^2}$

C. $K_p = \dfrac{\alpha P^2}{1-\alpha^2}$

D. $K_p = \dfrac{a^2 P}{1-\alpha^2}$

Answer: D

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10. When pressure is applied to the equilibrium system, $Ice \Leftrightarrow Water.$ Which of the following phenomenon will happen?

A. More ice will be formed

B. Water will evaporate

C. More water will be formed

D. Equilibrium will not be formed

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11. According to le-Chatelier's principle, adding heat to a solid and liquid in equilibrium will cause the

A. amount of solid to decrease

B. amount of liquid to decrease

C. temperature to rise

D. temperature to fall

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12. The standard state Gibbs's energy change for the isomerisation reaction $cis-2-pentence \Leftrightarrow trans-2-pentence$ is $-3.67kJmol^{-1}$ at $400K$. If more $trans-2-pentence$ is added to the reaction vessel, then:

A. more $cis-2-pentence$ is formed

B. equilibrium shifts in the forward direction

C. equilibrium remains unlatered

D. more $trans-2-pentence$ is produced

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13. The equilibrium constant (K_p) for the reaction, $PCl_{5(g)} \Leftrightarrow PCl_{3(g)} + Cl_{2(g)}$ is 16. If the volume of the container is reduced to half of its original volume, the value of K_p for the reaction at the same temperature will be:

A. 32

B. 64

C. 16

D. 4

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14. A gas bulb is filled with NO_2 gas and immersed in an ice bath at $0^\circ C$, which becomes colourless after sometime. This colourless gas will be:

A. NO_2

B. N_2O

C. N_2O_4

D. N_2O_5

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15. At equilibrium $K_p = 1$, then :

A. $\Delta G^\circ = 0$

B. $\Delta G^\circ = +ve$

C. $\Delta G^\circ = -ve$

D. none of these

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16. In which of the following case does the reaction go farthest to completion?

A. $K = 10^3$

B. $K = 10^2$

C. $K = 10$

D. $K = 1$

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17. If 1.0mole of I_2 is introduced in a $1.0 litre$ flask at $1000K \left(K_c = 10^{-6}\right)$, which one is correct?

A. $\left[I_{2(g)}\right] > \left[I^{-}_{(g)}\right]$

B. $\left[I_{2(g)}\right] < \left[I^{-}_{(g)}\right]$

C. $\left[I_{2(g)}\right] = \left[I^{-}_{(g)}\right]$

D. $\left[I_{2(g)}\right] = 1/2\left[I^{-}_{(g)}\right]$

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18. Which one is reversible process?

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

B. Mixing of two gases

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

D. none of these

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19. For the reaction, $N_2 + 3H_2 \Leftrightarrow 2NH_3$, in a vessel equal moles of N_2 and H_2 are mixed to attain equilibrium. At equilibrium:

A. $[N_2] = [H_2]$

B. $[N_2] > [H_2]$

C. $[N_2] < [H_2]$

D. $[H_2] > [NH_3]$

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20. 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. from left to right

B. from right to left

C. equilibrium

D. either of these

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21. If the pressure of N_2/H_2 mixture in a closed vessel is 100 atmospheres and 20% of the mixture then reacts the pressure at the same temperature would be .

A. 100

B. 90

C. 85

D. 80

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22. If $340g$ of a mixture of N_2 and H_2 in the correct ratio gas a 20% yield of NH_3. The mass produced would be:

A. $16g$

B. $17g$

C. $20g$

D. $68g$

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23. Hot copper turnings can be used as oxygen getter for inert gas supplies by slowly passing the gas over the turnings at $600K$.

$2Cu_{(s)} + 1/2O_{2(g)} \Leftrightarrow Cu_2O_{(s)}$,

$\left(K_p = 7.5 \times 10^{10} atm^{-\frac{1}{2}}\right)$. The number of molecules per litre left after equilibrium has reached are:

A. 2.17

B. 2.17×10^{23}

C. 3.61×10^{24}

D. 1.78×10^{22}

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24. The equilibrium constant K_c for $A(g) \Leftrightarrow B(g)$ is 1.1. Which gas has a molar concentration greater than 1.

A. $[A] = 0.91$

B. $[A] > 0.91$

C. $[A] > 1$

D. all of these

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25. Amount of PCl_5 (in moles) need to be added to one litre vessel at $250^\circ C$ in order to obtain a concentration of 0.1mole of Cl_2 for the given change is:

$PCl_5 \Leftrightarrow PCl_3 + Cl_2 , K_c = 0.0414 mollitre^{-1}$

A. 0.3415

B. 0.0341

C. 3.415

D. 0.3145

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26. For $NH_4HS(s) \Leftrightarrow NH_3(g) + H_2S(g)$, the observed, pressure for reaction mixture in equilibrium is 1.12 atm at $106^\circ C$. What is the value of K_p for the reaction?

A. $3.316atm^2$

B. $0.3136atm^2$

C. $31.36atm^2$

D. $6.98atm^2$

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27. In the reaction $C(s) + CO_2(g) \Leftrightarrow 2CO(g)$, the equilibrium pressure is 12 atm. If 50% of CO_2 reacts, calculate K_p.

A. $12atm$

B. $16atm$

C. $20atm$

D. $6atm$

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28. 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 is 1.7 and 5.3 respectively. Calculate equilibrium constant for the formation of S_3^{2-} from S_2^{2-} and S.

A. 1.33

B. 3.11

C. 4.21

D. 1.63

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29. If $CuSO_4.5H_2O_{(s)} \Leftrightarrow CuSO_4.3H_2O_{(s)} + 2H_2O_{(l)} K_p = 1.086 \times 10^{-4} atm^2$ at $25^\circ C$. The efflorescent nature of $CuSO_4.5H_2O$ can be noticed when vapour pressure of H_2O in atmosphere is

A. $> 7.92mm$

B. $< 7.92mm$

C. $\overset{>}{<} 7.92mm$

D. none of these

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30. For the reaction at $25^\circ C$, $N_2O_{4(g)} \Leftrightarrow 2NO_{2(g)}$, if ΔG_f° for N_2O_4 and NO_2 are 23.49 and $12.39 kcal$ respectively, then K_p for the reaction is:

A. 113332

B. 11.33

C. 1.133

D. 0.113

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31. The reaction $A_{(s)} \Leftrightarrow B_{(s)} + C_{(g)}$ attains equilibrium in a close container in such a way that vapour pressure of $C_{(g)}$ is equal to $1atm$. The incorrect realtionship at equilibrium is:

A. $\Delta G = 0$

B. $K_p = 1$

C. $\Delta G^{\circ} = 0$

D. $\Delta H^{\circ} = 0$

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32. In the system $AB_{(s)} \Leftrightarrow A_{(g)} + B_{(g)}$ doubling the quantity of $AB_{(s)}$ would:

A. increase the amount of A to double its value

B. increase the amount of B to double its value

C. increase the amounts of both A and B to double their values

D. cause no change in the amounts of A and B

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33. In the system $A_{(s)} \Leftrightarrow 2B_{(g)} + 3C_{(g)}$, if the concentration of C at equilibrium is increased by a factor of 2, it will cause the equilibrium concentration of B to change to:

A. two times the original value

B. one half of its original value

C. $2\sqrt{2} \times$ its original value

D. $\frac{1}{2\sqrt{2}} \times$ its original value

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34. The reaction quotient (Q) predicts:

A. the direction of equilibrium to be attained

B. the ratio of activities at equilibrium i.e., K_c

C. the ratio of activities at any-time

D. all of these

Answer: D

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35. Given a system in equilibrium, an increase in concentration of the products is always produced by arise in temperature, when the reaction is:

A. gas phase

B. spontaneous

C. exothermic

D. endothermic

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36. For the reaction is equilibrium :

$$2NOBr_{(g)} \Leftrightarrow 2NO_{(g)} + Br_{2(g)}$$

If P_{Br_2} is $\frac{P}{9}$ at equilibrium and P is total pressure, prove that $\frac{K_p}{P}$ is equal to $\frac{1}{81}$.

A. $1/9$

B. $1/81$

C. $1/27$

D. $1/3$

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37. N_2O_4 is dissociated to 33% and 40% at total pressure P_1 and P_2 atm respectively. Then the ratio P_1/P_2 is

A. $7/4$

B. $7/3$

C. $8/3$

D. $8/5$

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38. Assertion: A dynamic equilibrium means a balance between the tendency towards minimum and maximum enthalpy .

Reason: The reaction having $\Delta H = -ve$ occurs form high enthalpy side to low enthalpy side and the reaction $\Delta H = +ve$ occurs form low enthalpy side to high enthalpy side.

A. a tendency towards minimum enthalpy

B. a tendency towards maximum enthalpy

C. a balance between the tendencies towards minimum and maximum enthalpies

D. none of these

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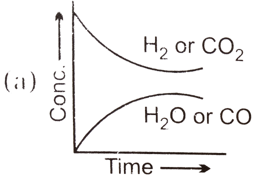
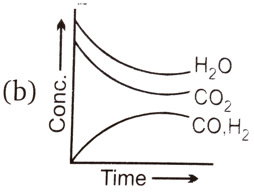
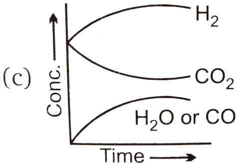
39. Which of the following graphs are correct for the given reaction?

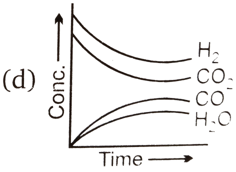
$$H_{2(g)} + CO_{2(g)} \Leftrightarrow H_2O_{(g)} + CO_{(g)}$$

Assume initially only H_2 and CO_2 are present:

A. 

B. 

C. 

D. 

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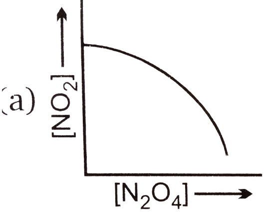
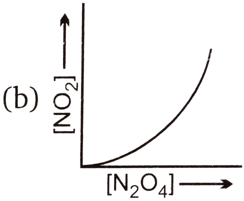
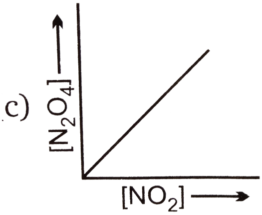
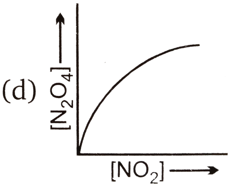
40. If the equilibrium constant for the reaction, $N_2O_4 \Leftrightarrow 2NO_2$ is $K = [NO_2]^2 / [N_2O_4]$, then which of the graphs are correct at constant temperature?

A. 

B. 

C. 

D. 

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41. Which of the following is correct if reaction quotient $(Q) = 1$?

A. $\Delta G = 0$

B. $\Delta G^{\circ} = 0$

C. $\Delta S^{\circ} = 0$

D. $\Delta G = \Delta G^{\circ}$

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42. Which statement about the given reaction is incorrect?

$N_2 + 3H_2 \Leftrightarrow 2NH_3, \Delta H = -ve$

A. At $200^{\circ} C$, the yield of NH_3 is 15%

B. At $500^{\circ} C$, the yield of NH_3 is 15%

C. At $1000^{\circ} C$, the yield of NH_3 is 1%

D. The reaction occurs at faster rate to attain equilibrium earlier at $500^{\circ} C$

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43. Which oxide of nitrogen is the most stabel?

A. $2NO_{2(g)} \Leftrightarrow N_{2(g)} + 2O_{2(g)}, K = 6.7 \times 10^{16} mollitre^{-1}$

B. $2NO_{(g)} \Leftrightarrow N_{2(g)} + O_{2(g)}, K = 2.2 \times 10^{30} mollitre^{-1}$

C. $2N_2O_{5(g)} \Leftrightarrow 2N_{2(g)} + 5O_{2(g)}, K = 1.2 \times 10^{34} mol^5 litre^{-5}$

D. $2N_2O_{(g)} \Leftrightarrow 2N_{2(g)} + O_{2(g)}, K = 3.5 \times 10^{33} mollitre^{-1}$

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44. Pure ammonia is placed in a vessel at a temperature where its dissociation constant (α) is appreciable. At equilibrium,

A. K_p does not change with pressure

B. α does not change with pressure

C. $[NH_3]$ does not change with pressure

D. $[H_2] < [N_2]$

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45. Indicate the correct answer out of the following for the reaction:

$NH_4Cl + H_2O \Leftrightarrow NH_4OH + HCl$

A. the reaction is retarded by the addition of KOH

B. the reaction is favoured by the addition of NH_4OH

C. the reaction is retarded by the addition of hydrogen ion

D. none of these

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46. Hydrogen and oxygen were heated together in a closed vessel. The equilibrium constant is found to decrease after $2000^{\circ}C$. Which is responsible for this?

A. Backward reaction predominates

B. Forward reaction predominates

C. Both forward and backward reaction have same rate

D. It is a property of the system, hence no reason for lower value

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47. In line kilns, the following reaction,

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

proceeds to completion because of

A. of high temperature

B. CO_2 escapes out

C. CaO is removed

D. of low temperature

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48. A change in the free energy of a system at constant temperature and pressure will be:

$\Delta_{sys}G = \Delta_{sys}H - T\Delta_{sys}S$

At constant temperature and pressure

$\Delta_{sys}G < 0$ (spontaneous)

$\Delta_{sys}G = 0$ (equilibrium)

$\Delta_{sys}G > 0$ (non-spontaneous)

For a system in equilibrium, $\Delta G = 0$, under conditions of constant

A. temperature and pressure

B. temperature and volume

C. energy and volume

D. pressure and volume

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49. In $K_p = K_c(RT)^{\Delta n}$, Δn may have:

A. $+ve$ values

B. $-ve$ values

C. integer or fractional values either of these

D. either of these

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50. When a bottle of cold drink is opened, the gas comes out with a fizzle due to:

A. decrease in pressure suddenly which results in a decrease in solubility of CO_2 gas in water.

B. decrease in temperature

C. increase in pressure

D. none of these

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51. Densities of diamond and graphite are 3.5 and $2.3 gmL^{-1}$, respectively. The increase of pressure on the equilibrium $C_{\text{diamond}} \Leftrightarrow C_{\text{graphite}}$

A. favours backward reaction

B. favours forward reaction

C. have no effect

D. nothing can be predicted

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52. The reaction which proceeds in the forward direction is

A. $SnCl_4 + Hg_2Cl_2 \Leftrightarrow SnCl_2 + 2HgCl_2$

B. $NH_4Cl + NaOH \Leftrightarrow H_2O + NH_3 + NaCl$

C. $Mn^{2+} + 2H_2O + Cl_2 \Leftrightarrow MnO_2 + 4H^+ + 2Cl$

D. $S_2O_6^{2-} + 3I^- \Leftrightarrow 2S_2O_3^{2-} + I_2$

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53. For the reactions,

$A \Leftrightarrow B \quad K_c = 2$
$B \Leftrightarrow C \quad K_c = 4$
$C \Leftrightarrow D \quad K_c = 6$

K_c for the reaction, $A \Leftrightarrow D$ is:

A. $(2+4+6)$

B. $(2 \times 4)/6$

C. $(4 \times 6)/2$

D. $2 \times 4 \times 6$

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54. If pressure is applied to the equilibrium of solid-liquid. The melting point of the solid:

A. will not change

B. may increase or decrease depending upon nature of solid species

C. will always increase

D. will always decrease

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55. Solubility of a gas in liquid increases on:

A. addition of a catalyst

B. increasing the pressure

C. decreasing the pressure

D. increasing temperature

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56. 2mole of PCl_5 were heated in a closed vessel of $2litre$ capacity. At equilibrium 40% of PCl_5 dissociated into PCl_3 and Cl_2. The value of the equilibrium constant is:

A. 0.267

B. 0.53

C. 2.63

D. 5.3

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57. If in reaction, $N_2O_4 \Leftrightarrow 2NO_2$, α is degree of dissociation of N_2O_4, then the number of molecules at equilibrium will be:

A. 3

B. $(1-\alpha)$

C. $(1-\alpha)^2$

D. $(1+\alpha)$

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58. For the reaction $CH_{4(g)} + 2O_{2(g)} \Leftrightarrow CO_{2(g)} + 2H_2O_l$:

($\Delta H = -170.8 kJmol^{-1}$). Which of the following statement is not true?

A. Addition of $CH_{4(g)}$ or $O_{2(g)}$ at equilibrium will cause a shift to right

B. The reaction is exothermic

C. At equilibrium , the concentration of $CO_{2(g)}$ and H_2O_l are not equal

D. The equilibrium constant for the reaction is given by $K_p = \dfrac{[CO_2]}{[CH_4][O_2]^2}$

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59. A reaction $CaF_2 \Leftrightarrow Ca^{2+} + 2F^-$ is at equilibrium. If the concentration of Ca^{2+} is increased four times, what will be the change in F^- concentration as compared to the initial concentration of F^-?

A. $1/4$ of the initial value

B. $1/2$ of the initial value

C. 2 times of the initial value

D. none of these

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60. 28 g of N_2 and 6 g of H_2 were mixed. At equilibrium 17 g NH_3 was produced. The weight of N_2 and H_2 at equilibrium are respectively

A. $11g$, zero

B. $1g, 3$

C. $14g, 3g$

D. $11g, 3g$

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61. If ΔG° for the reaction given below is $1.7kJ$, the equilibrium constant of the reaction,

$2HI_{(g)} \Leftrightarrow H_{2(g)} + I_{2(g)}$ at $25^\circ C$ is :

A. 24.0

B. 3.9

C. 2.0

D. 0.5

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62. The equilibrium constant of a reaction is 1×10^{20} at $300K$. The standard free energy change for this reaction is :

A. $-115kJ$

B. $+115kJ$

C. $+166kJ$

D. $-166kJ$

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63. The equilibrium constant of a reaction is 20.0. At equilibrium, the reate constant of forward reaction is 10.0. The rate constant for backward reaction is :

A. 0.5

B. 2.0

C. 10.0

D. 200.0

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

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

with degree of dissociation α, which is small compared with unity. The expression for K_p in terms of α and the total pressure P_T is

A. $\dfrac{Px^3}{2}$

B. $\dfrac{Px^2}{3}$

C. $\dfrac{Px^3}{3}$

D. $\dfrac{Px^2}{2}$

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65. For the reaction

$Ag(CN)_2^{\ominus} \Leftrightarrow Ag^{\oplus} + 2CN^{\ominus}$, the K_c at $25^\circ C$ is 4×10^{-19} Calculate $[Ag^{\oplus}]$ in solution which was originally $0.1M$ in KCN and $0.03M$ in $AgNO_3$.

A. 7.5×10^{18}

B. 7.5×10^{-18}

C. 7.5×10^{19}

D. 7.5×10^{-19}

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66. When $20g$ of $CaCO_3$ were put into $10litre$ flask and heated to $800^\circ C$, 35% of $CaCO_3$ remained unreacted at equilibrium. K_p for decomposition of $CaCO_3$ is :

A. $1.145atm$

B. $0.145atm$

C. $2.146atm$

D. $3.145atm$

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67. $2\text{mole}N_2$ and $3\text{mole}H_2$ gas are allowed to react in a $20L$ flask at $400K$ and after complete conversion of H_2 into NH_3. $10LH_2O$ was added and temperature reduced to $300K$. Pressure of the gas after reaction is :

$N_2 + 3H_2 \rightarrow 2NH_3$

A. $3R \times 300/20$

B. $3R \times 300/10$

C. $R \times 300/20$

D. $R \times 300/10$

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68. At $298K$, the equilibrium between N_2O_4 and NO_2 is represented as : $N_2O_{4(g)} \Leftrightarrow 2NO_{2(g)}$. If the total pressure of the equilibrium mixture is

P and the degree of dissociation of $N_2O_{4(g)}$ at $298K$ is x, the partial pressure of $NO_{2(g)}$ under these conditions is:

A. $\left(\frac{2x}{1+x}\right)P$

B. $2xP$

C. $\left(\frac{2x}{1-x}\right)P$

D. $\frac{2}{3}xP$

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69. The equilibrium constant (K_p) for the reaction, $2SO_2 + O_2 \Leftrightarrow 2SO_3$ at $1000K$ is 3.5. The partial pressure of oxygen gas to give equal mole of SO_2 and SO_3 is :

A. $0.29atm$

B. $35atm$

C. $0.53atm$

D. $1.87atm$

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70. A mixture of nitrogen and hydrogen in the ratio of $1:3$ reach equilibrium with ammonia, when 50% of the mixture has reacted. If the total pressure is P, the partial pressure of ammonia in the equilibrium mixture was :

A. $P/2$

B. $P/3$

C. $P/4$

D. $P/6$

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71. For the reversible system : $X_{(g)} \Leftrightarrow Y_{(g)} + Z_{(g)}$, a quantity of X was heated at constant pressure P at a certain temperature. The equilibrium partial pressure of X was found to be $P/7$. What is the value of K_p at given temperature?

A. $6P/7$

B. $9P/7$

C. $36P/7$

D. $6P$

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72. What weight of solid ammonium carbamate (NH_2COONH_4), when vaporised at $200^\circ C$ will have a volume of $8.96 litre$ at $1.0 atm$ pressure. Assume that the solid completely decomposes into CO_2 and NH_3 at $200^\circ C$ and $1.0 atm$:

A. $4g$

B. $6g$

C. $5g$

D. $10g$

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73. Some gaseous equilibrium are given below:

$CO + H_2O \Leftrightarrow CO_2 + H_2$

$2CO + O_2 \Leftrightarrow 2CO_2$

$2H_2 + O_2 \Leftrightarrow 2H_2O$

find out the realation between equilibrium constants:

A. $K = K_1K_2$

B. $K = (K_1K_2)^2$

C. $K = (K_1 / K_2)^{1/2}$

D. $K = K_1 / K_2$

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74. 8 mol of gas AB_3 are introduced into a $1.0 dm^3$ vessel. It dissociates as $2AB_3(g) \Leftrightarrow A_2(g) + 3B_2(g)$

At equilibrium, 2 mol of A_2 is found to be present. The equilibrium constant for the reaction is

A. $72 mol^2 L^{-2}$

B. $36 mol^2 L^{-2}$

C. $3 mol^2 L^{-2}$

D. $27 mol^2 L^{-2}$

Answer: D

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75. If S° for N_2, O_2, N_2O, NO_2, NO and N_2O_4 are 45.7, 49.0, 48.2, 57.24 and 72.77 cal respectively and

$$N_2+\frac{1}{2}O_2 \Leftrightarrow N_2O \quad \Delta H^{\circ}=19.49kcalat27^{\circ}C$$
$$\frac{1}{2}N_2+\frac{1}{2}O_2 \Leftrightarrow NO \quad \Delta H^{\circ}=21.60kcalat27^{\circ}C$$
$$\frac{1}{2}N_2+O_2 \Leftrightarrow NO_2 \quad \Delta H^{\circ}=8.09kcalat27^{\circ}C$$
$$N_2+2O_2 \Leftrightarrow N_2O_4 \quad \Delta H^{\circ}=2.19kcalat27^{\circ}C$$

For which ΔG° is more $+ve$?

A. NO

B. N_2O

C. NO_2

D. N_2O_4

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76. The degree of dissociation of $PCl_5(\alpha)$ obeying the equilibrium, $PCl_5 \Leftrightarrow PCl_3+Cl_2$ is related to the pressure at equilibrium by :

A. $a \propto P$

B. $a \propto \frac{1}{\sqrt{P}}$

C. $a \propto \frac{1}{P^2}$

D. $a \propto \frac{1}{P^4}$

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77. The plots of $\log_{10} K vs. 1/T$ leads toa straight line having intercept equal to:

A. ΔG°

B. $\frac{\Delta G^\circ}{2.303R}$

C. $\frac{\Delta S^\circ}{2.303R}$

D. $\frac{\Delta H^\circ}{2.303R}$

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78. For an equilibrium reaction involving gases, the forward reaction is first order while the reverse reaction is second order. The unit of K_p for forward equilibrium is

A. atm

B. atm^2

C. atm^{-1}

D. atm^{-2}

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79. For the reaction, $A + B \Leftrightarrow 3C$, at $25^{\circ} C$, a $3litre$ vessel contains 1, 2, $4moles$ of A, B and C respectively. If K_c for the reaction is 10, the reaction will proceed in :

A. forward direction

B. backward direction

C. in either direction

D. in equilibrium

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80. The brown gas prepared by the action of concentrated nitric acid on copper is an equilibrium mixture of dinitrogen tetraoxide and nitrogen dioxide : $N_2O_{4(g)} \xLeftrightarrow{Enhermic} 2NO_{2(g)}$

Which one of the following changes would result in a darkening of the colour?

A. Increase in pressure

B. Increase in temperature

C. Addition of a catalyst

D. Removal of dinitrogen tetraoxide by liquefaction

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81. The dissociation equilibrium pressure of $NH_4HS_{(s)}$ is $60cm$ at $27^\circ C$. The total pressure at equilibrium, when the NH_4HS is dissociated in pressence of $45cm$ of NH_3 is :

A. $100cm$

B. $105cm$

C. $75cm$

D. $65cm$

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82. If little heat is added to $Ice \Leftrightarrow Liquid$ equilibrium in a sealed container :

A. Pressure will rise

B. Pressure will fall

C. Temperature will fall

D. Temperature remains constant

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83. 0.2mole of NH_4Cl are introduced into an empty container of $10 litre$ and heated to $327^\circ C$ to attain equilibrium as : $NH_4Cl_{(s)} \Leftrightarrow NH_{3(g)} + HCl_{(g)}, \left(K_p = 0.36 atm^2\right)$.

The quantity of solid NH_4Cl left is :

A. 0.078mole

B. 0.02mole

C. 0.095mole

D. 0.035mole

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84. The equilibrium : $PCl_{5(g)} \Leftrightarrow PCl_{3(g)} + Cl_{2(g)}$ shows that $K_p(atm)$ is double to the value of K_c $(mollitre^{-1})$ at a particular temperature T, then T is :

A. $2K$

B. $12.18K$

C. $24.36K$

D. $27.3K$

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85. The relation between K_p and K_c of a reversible reaction at constant temperature is K_p=..............

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. $K_c = K_p(RT)^{-\Delta n}$

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86. For the gas phase reaction

$C_2H_4 + H_2 \Leftrightarrow C_2H_6(\Delta H = -32.7\text{kcal})$

carried out in a vessel, the equilibrium concentration of C_2H_4 can be increased by

A. increasing the temperature

B. decreasing the temperature

C. removing some H_2

D. adding some C_2H_6

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87. Nitrogen combines with oxygen to form nitric oxide,

$N_{2(g)} + O_{2(g)} \Leftrightarrow 2NO_{(g)}$, $(\Delta H = 90 kJmol^{-1})$

The decomposition of NO is favoured by:

A. decrease of temperature

B. increase of temperature

C. increase in the concentration of nitric oxide

D. decrease of pressure

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88. A reaction $S_8(g) \Leftrightarrow 4S_2(g)$ is carried out by taking 2 mol of $S_8(g)$ and 0.2 mol of $S_2(g)$ is a reaction vessel of $1L$. Which one is not correct if $K_c = 6.30 \times 10^{-6}$

A. Reaction quotient is 8.0×10^{-4}

B. $K_p = 2.55 atm^3$

C. Reaction proceeds in forward direction

D. Reaction proceeds in backward direction

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89. Which is/are true for a reversible reaction?

A. The reaction is never completed

B. The reactants are present in the initial stage but after that reactants and products are always present in the reaction mixture

C. At equilibrium only products are present

D. When the gaseous phase reaction is carried out in closed space, it attains equilibrium state after suitable time

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90. In a chemical reaction, equilibrium is said to have been established when the

A. the concentrations of the reactants and product are equal

B. the rate of the opposing reactions become equal

C. the temperature of the opposing reactions are equal

D. there is no change in the concentration of either the product or the rectant with time.

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91. Which of the following equilibrium reactions would be affected by change in pressure?

A. $N_2 + O_2 \Leftrightarrow 2NO$

B. $2SO_2 + O_2 \Leftrightarrow 2SO_3$

C. $PCl_5 \Leftrightarrow PCl_3 + Cl_2$

D. $H_2 + Cl_2 \Leftrightarrow 2HCl$

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92. Which of the following is /are true?

A. $H_2S + H_2O \Leftrightarrow H_3O^+ + HS^-$, K_c acidity constant of H_2S

B. $AgCl + 2NH_3 \Leftrightarrow Ag(NH_3)_2Cl$, K_c is stability constant for $Ag(NH_3)_2Cl$

C. $H_2O \Leftrightarrow H^+ + OH^-$, K_c is equilibrium constant for dissociation of water

D. $RNH_2 + H_2O \Leftrightarrow RNH_3^+ + OH^-$, K_c is basicity constant for RNH_2

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93. 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 $CO_{(g)}$

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94. For the reaction,

$PCl_{5(g)} \Leftrightarrow PCl_{3(g)} + Cl_{2(g)}$, the forward reaction at constant temperature is favoured by:

A. introducing an inert gas at constant volume

B. introducing PCl_5 at constant volume

C. introducing an inert gas at constant pressure

D. increasing the volume of the container

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95. The equilibrium $SO_2Cl_2(g) \Leftrightarrow SO_2(g) + Cl_2(g)$ is attained at $25^\circ C$ in a closed container and an inert gas, helium, is introduced. Which of the following statement is / are correct?

A. concentrations of SO_2, Cl_2 and SO_2Cl_2 are changed

B. More Cl_2 is formed

C. Concentration of SO_2 is reduced

D. More SO_2Cl_2 is formed.

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96. The pressure (P) and volume (V) of an ideal gas both increase in a process:

A. Such a process is not possible

B. The work done by the system is positive

C. The temperature of the system must increase

D. Heat supplied to gas is equal to the change in internal energy

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97. For the reaction,

$2HCl_{(g)} \Leftrightarrow H_{2(g)} + Cl_{2(g)}$, the equilibrium constant is 1.0×10^{-5}.

What is the concentration of HCl if the equilibrium concentrations of H_2 and Cl_2 are $1.2 \times 10^{-8} M$ and $1.2 \times 10^{-9} M$ respectively?

A. $1.2 \times 10^{-3} M$

B. $1.2 \times 10^{-7} M$

C. $1.2 \times 10^{-4} M$

D. $1.2 \times 10^{-6} M$

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98. For which of the following reaction (s) is (are) $K_p = K_c$?

A. $H_{2(g)} + I_{2(g)} \Leftrightarrow 2HI_{(g)}$

B. $2N_2O_{4(g)} \Leftrightarrow 4NO_{2(g)}$

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

D. $H_{2(g)} + Cl_{2(g)} \Leftrightarrow 2HCl_{(g)}$

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99. A chemical reaction, $A \rightarrow B$ is said to be in equilibrium when:

A. 50% of the conversion has taken place

B. only 10% conversion of A to B has taken place

C. the rate of transformation of A to B is just equal to the rate of transformation of B to A in the system

D. there is no change in the concentration of either A or B

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100. Which of the following statement (s) is/are true about reaction quotient (Q)?

A. $Q \overset{>}{<} K_c$

B. Q always increases if reaction proceeds in forward direction

C. $Q = K_c = 1$, at equilibrium

D. $Q = K_c$, at equilibrium

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101. Which of the following statement (s) is/are true about reaction quotient (Q)?

A. At time proceeds, Q either decreases or increases

B. $Q \overset{>}{<} K_p$

C. $Q = 1$ at equilibrium

D. $Q = K_p$ at equilibrium

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102. For the reaction, $PCl_3(g) + Cl_2(g) \Leftrightarrow PCl_5(g)$, the position of equilibrium can be shifted to the right by:

A. increasing the temperature

B. Compressing the gaseous mixture

C. Increasing the volume of the gaseous mixture

D. Adding $Cl_{2(g)}$ to the equilibrium mixture at a constant volume

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

A. addition of $NaNO_2$ favours reverse reaction

B. addition of $NaNO_3$ favours forward reaction

C. increasing temperature favours forward reaction

D. increasing pressure favours reverse reaction

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104. The rate of effusion of an equilibrium mixture in $1 litre$ vessel of, at $300K, A_2 \Leftrightarrow 2A$ through a pinhole is 0.707 times of rate of diffusion on O_2 under identical conditions of P and T. Which of the following is/are correct if at. Wt. of A is 46?

A. $K_c = 25.16 mol litre^{-1}$

B. mole ration of $\dfrac{A}{A_2} = 0.643$

C. mol.wt. of mixture $= 56$

D. $\Delta G^\circ = -8.01 \times 10^3 J$

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105. Reaction between barium chloride and sodium sulphate goes to completion because:

A. barium sulphate is almost insoluble

B. the reaction is reversible

C. the solubility of barium chloride decreases

D. the reaction is irreversible

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106. The equilibrium constant of the reactions

$$SO_2(g)+\frac{1}{2}O_2(g)\Leftrightarrow SO_3(g)$$

and $2SO_2(g)+O_2 \Leftrightarrow 2SO_3(g)$

are K_1 and K_2 respectively. The relationship between K_1 and K_2 is

A. $K_1=K_2$

B. $K_2=K_1$

C. $K_1 = \sqrt{K_2}$

D. $K_2 = \sqrt{K_1}$

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107. Plots of $\log vs. \frac{1}{T}$ plots shows an intercept of 2 on $y-$ axis with a slope of 45° for the studied reaction. Assuming that ΔH° and ΔS° as temperature independent, select the correct statement (s).

A. $\Delta G^\circ = -2.75 kcal$

B. $\Delta S^\circ = 4.606 kcal$

C. $H^\circ = -4.606 cal$

D. $K = 100.8$

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108. The decomposition of HNO_3 represented below attains equilibrium at a given $P_{eq.}$ and $T.$ If we start: $4HNO_{3(g)} \Leftrightarrow 4NO_{2(g)} + 2H_2O_{(g)} + O_{2(g)}$ with pure HNO_3 having initial pressure P_i, then at equilibrium. Select the correct statement (s).

A. $K_p = \dfrac{1024(P_{O_2})^7}{(P_{eq.} - 7P_{O_2})^4}$

B. $K_p = \dfrac{1024(P_{O_2})^7}{(P_i - 4P_{O_2})^4}$

C. $K_p = \dfrac{1024(P_{O_2})^7}{(P_{eq.} - 7P_{O_2})^4} \times \left(\dfrac{1}{(p^\circ)^3}\right)$

D. none of these

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109. In which of the following equilibrium, change in the volume of the system does not alter the number of moles?

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

B. $PCl_{5(g)} \Leftrightarrow PCl_{3(g)} + Cl_{2(g)}$

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

D. $SO_2Cl_{2(g)} \Leftrightarrow SO_{2(g)} + Cl_{2(g)}$

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110. In which of the following reactions, increase in the pressure at temperature does not affect the moles at equilibrium:

A. $2NH_{3(g)} \Leftrightarrow N_{2(g)} + 3H_{2(g)}$

B. $C_{(g)} + 1/2O_{2(g)} \Leftrightarrow CO_{(g)}$

C. $H_{2(g)} + 1/2O_{2(g)} \Leftrightarrow H_2O_{(g)}$

D. $H_{2(g)} + I_{2(g)} \Leftrightarrow 2HI_{(g)}$

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111. K_p / K_c for the reaction

$CO(g) + \frac{1}{2}O_2(g) \Leftrightarrow CO_2(g)$ is

A. RT

B. $(RT)^{-1}$

C. $(RT)^{-1/2}$

D. $(RT)^{1/2}$

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112. For the reaction equilibrium, $N_2O_{4(g)} \Leftrightarrow 2NO_{2(g)}$, the concentration of N_2O_4 and NO_2 at equilibrium are 4.8×10^{-2} and 1.2×10^{-2} mol/L respectively. The value of K_c for the reaction is:

A. $3 \times 10^{-3}M$

B. $3 \times 10^{3}M$

C. $3.3 \times 10^2 M$

D. $3 \times 10^{-1} M$

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113. Consider the reaction equilibrium, $2SO_{2(g)} + O_{2(g)} \Leftrightarrow$, $\Delta H^\circ = -198kJ$. On the basis of Le-Chatelier's principle, the condition favourable for the forward reaction is

A. low temperature, high pressure

B. any value of T and P

C. low temperature and low pressure

D. high temperature and high pressure

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114. What is the equilibrium expression for the reaction

$P_{4(s)} + 5O_{2(g)} \Leftrightarrow P_4O_{10(s)}$?

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

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

C. $K_c = [O_2]^5$

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

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115. For the reaction $CO(g) + Cl_2(g) \leftrightarrow COCl_2(g)$, K_p / K_c is equal to:

A. 1.0

B. RT

C. $\sqrt{RT}$

D. $1/RT$

116. The equilibrium constant for the reaction

$N_2(g) + O_2(g) \Leftrightarrow 2NO(g)$

at temperature T is 4×10^{-4}.

The value of K_c for the reaction

$NO(g) \Leftrightarrow \frac{1}{2}N_2(g) + \frac{1}{2}O_2(g)$

at the same temperature is

A. 0.02

B. 50

C. 4×10^{-4}

D. 2.5×10^{-2}

117. The exothermic formation of ClF_3 is represented by thr equation:

$Cl_2(g) + 3F_2(g) \Leftrightarrow 2ClF_3(g), \Delta H = -329kJ$

Which of the following will increase the quantity of ClF_3 in an equilibrium mixture of Cl_2, F_2, and ClF_3?

A. increasing the temperature

B. Removing Cl_2

C. Increasing the volume of container

D. Adding F_2

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118. For the reaction, $2NO_{2(g)} \Leftrightarrow 2NO_{(g)} + O_{2(g)} K_c = 1.0 \times 10^{-6}$ at $184^\circ C$ and $R = 0.083 jK^{-1} \text{mol}^{-1}$. When K_p and K_c are compared at $184^\circ C$, it is found that:

A. $K_p > K_c$

B. $K_p < K_c$

C. $K_p = K_c$

D. $K_p \overset{<}{>} K_c$ depends upon pressures of gases

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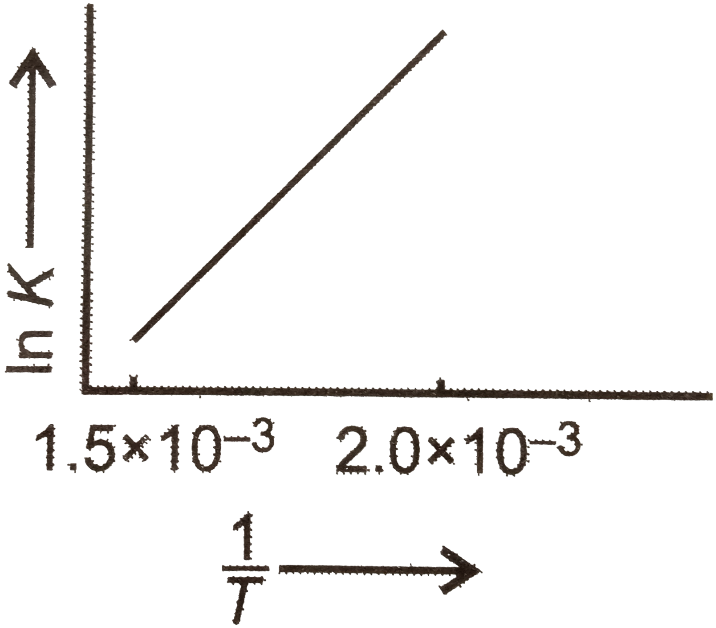
119. The graph relates. In $K_{eq}. vs. \frac{1}{T}$ for a reaction. The reaction must be:



A. exothermic

B. endothermic

C. ΔH is negligible

D. high spontaneous at ordinary temperature

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120. A definite amount of solid NH_4HS is placed in a flask aleady containing ammoina gas at a certain temperature and 0.50 atm pressure. NH_4HS decomposes to give NH_3 and H_2S and at equilibrium total pressure in flask is 0.84 atm. The equilibrium constant for the reaction is:

A. 0.30

B. 0.18

C. 0.17

D. 0.11

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121. PCl_5 dissociation a closed container as :

$$PCl_{5(g)} \Leftrightarrow PCl_{3(g)} + Cl_{2(g)}$$

If total pressure at equilibrium of the reaction mixture is P and degree of dissociation of PCl_5 is α, the partial pressure of PCl_3 will be:

A. $P.\left[\frac{\alpha}{\alpha+1}\right]$

B. $P.\left[\frac{2\alpha}{1-\alpha}\right]$

C. $P.\left[\frac{\alpha}{\alpha-1}\right]$

D. $P.\left[\frac{\alpha}{1-\alpha}\right]$

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122. The equilibrium constant for the given reaction:

$$SO_{3(g)} \Leftrightarrow SO_{2(g)} + 1/2O_{2(g)}, \left(K_c = 4.9 \times 10^{-2}\right)$$

The value of K_c for the reaction:

$2SO_{2(g)} + O_{2(g)} \Leftrightarrow 2SO_{3(g)}$, will be :

A. 416

B. 2.40×10^{-3}

C. 9.8×10^{-2}

D. 4.9×10^{-2}

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123. 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. $1:36$

B. $1:1$

C. $1:3$

D. $1:9$

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124. For the following three reaction 1, 2 and 3, equilibrium constants are given:

(1) $CO_{(g)} + H_2O_{(g)} \Leftrightarrow CO_{2(g)} + H_{2(g)}, K_1$

(2) $CH_{4(g)} + H_2O_{(g)} \Leftrightarrow CO_{(g)} + 3H_{2(g)}, K_2$

(3) $CH_{4(g)} + 2H_2O_{(g)} \Leftrightarrow CO_{2(g)} + 4H_{2(g)}, K_3$

Which of the following relations is correct ?

A. $K_1\sqrt{K_2} = K_3$

B. $K_2K_3 = K_1$

C. $K_3 = K_1K_2$

D. $K_3K_2^3K_1^2$

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125. For the reversible reaction

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

at $500^\circ C$, the value of K_p is 1.44×10^{-5} when the partial pressure is measured in atmosphere. The corresponding value of K_c with concentration in mol L^{-1} is

A. $1.44 \times 10^{-5} / (0.082 \times 500)^2$

B. $1.44 \times 10^{-5} / (8.314 \times 773)^2$

C. $1.44 \times 10^{-5} / (0.082 \times 500)^{-2}$

D. $1.44 \times 10^{-5} / (0.082 \times 773)^{-2}$

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126. When two reactants A and B are mixed to give products C and D, the reaction quotient (Q) at the initial stages of the reaction

A. is zero

B. decrease with time

C. independent of time

D. increase with time

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127. At constant temperature, the equilibrium constant (K_p) for the decomopsition reaction $N_2O_4 \Leftrightarrow 2NO_2$ is expressed by $K_p = \frac{(4x^2P)}{(1-x^2)}$, where P = pressure, x = extent of decomposition. Which one of the following statement is true ?

A. K_p increases with increases of P

B. K_p increases with increase of x

C. K_p increases with decreases of x

D. K_p remains constant with change in P or x

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128. Consider the following equilibrium in a closed container:

$N_2O_4(g) \Leftrightarrow 2NO_2(g)$

At a fixed temperature, the volume of the reaction container is halved. For this change which of the following statements holds true regarding the equilibrium constant (K_p) and degree of dissociation (α)?

A. Neither K_p nor α changes

B. Both K_p and α changes

C. K_p changes, but α does not change

D. K_p does not change, but α changes

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129. If $Ag^{+} + NH_3 \Leftrightarrow [Ag(NH_3)]^{+}$, $K_1 = 3.5 \times 10^{-3}$ and $[Ag(NH_3)]^{+} + NH_3 \Leftrightarrow \left[Ag(NH_3)_2\right]^{+}$, $K_2 = 1.74 \times 10^{-3}$. The formation constant of $\left[Ag(NH_3)_2\right]^{+}$ is :

A. 6.08×10^{-6}

B. 6.8×10^{-6}

C. 1.6×10^{3}

D. 1.088×10^{7}

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130. For the reaction : $N_{2(g)} + 3H_{2(g)} \Leftrightarrow 2NH_{3(g)}$, $\Delta H = -ve$, the correct statement is :

A. addition of catalyst does not change K_p but changes ΔH

B. at equilibrium, $2G_{NH_3} = G_{N_2} + 3H_{H_2}$ (G is Gibbs' energy)

C. at higher temperature, the rate of forward and backward reaction increases by a factor 2.

D. at $400K$, addition of catalyst increases rate of forward reaction by $2 \times$ and backward by $1.7 \times$.

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131. The value of $\log_{10} K$ for a reaction $A \Leftrightarrow B$ is (Given: $\Delta_f H^{\Theta}_{298K} = -54.07 kJ mol^{-1}$, $\Delta_r S^{\Theta}_{298K} = 10 JK^{=1} mol^{-1}$, and $R = 8.314 JK^{-1} mol^{-1}$

A. 5

B. 10

C. 95

D. 100

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132. A vessel at $1000K$ contains carbon dioxide with a pressure of $0.5atm$. Some of the carbon dioxide is converted to carbon monoxide on addition of graphite. Calculate the value of K_p if total pressure at equilibrium is $0.8atm$.

A. $1.8atm$

B. $3atm$

C. $0.3atm$

D. $0.18atm$

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133. The equilibrium constant for the reaction

$N_2(g) + O_2(g) \Leftrightarrow 2NO(g)$

at temperature T is 4×10^{-4}.

The value of K_c for the reaction

$NO(g) \Leftrightarrow \frac{1}{2}N_2(g) + \frac{1}{2}O_2(g)$

at the same temperature is

A. 2.5×10^2

B. 4×10^{-4}

C. 50.0

D. 0.02

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Integer

1. If a mixture of 3mole of H_2 and 1mole of N_2 is completely converted into NH_3, what would be the final volume at same P and T?

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2. For the reaction $C(s) + CO_2(g) \Leftrightarrow 2CO(g)$, the partial pressure of CO_2 and CO is 2.0 and 4.0 atm, respectively, at equilibrium. The K_p of the reaction is

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3. In the reaction, $PCl_5 \Leftrightarrow PCl_3 + Cl_2$, the amounts of PCl_5, PCl_3 and $Cl_2, 2mo \leq s$ each at equilibrium and the total pressure is $3atm$. Find the equilibrium constant K_p.

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4. For the equilibrium, $2NO_{(g)} + O_{2(g)} \Leftrightarrow 2NO_{2(g)}$, K_p is 1.24×10^{-2} at $27^\circ C$. Find the value of K_c at $727^\circ C$.

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5. Equilibrium constant K_p for

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

is 0.0118 atm at $1065^\circ C$ and heat of dissociation is 42.4 Kcal. Find equilibrium constant at $1132^\circ C$.

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6. For the equilibrium, $N_2O_4 \Leftrightarrow 2NO_2$, $\left(G^\circ_{N_2O_4}\right)_{298} = 100kJ/mol$ and $\left(G^\circ_{NO_2}\right)_{298} = 50kJ/mol.$

(a) When $5mo\frac{l}{l}itre$ of each is taken, calculate the value of ΔG for the reaction at $298K$.

(b) Find the direction of reaction.

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7. The molar concentration of A and B are $0.80 mol / litre$ each . On mixing them, the reaction starts to proceed as : $A + B \Leftrightarrow C + D$, and attain equilibrium. At equilibrium molar concentration of C is $0.60 mol / litre$. Find the value of K_c of the reaction.

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8. In a reaction at equilibrium, $'x'$ mole of reactant A decompose to give $1 molar$ of C and D. It has been found that the fraction of A decomposed at equilibrium is independent of initial concentration of A. Find the value of x.

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9. In the reaction $C_{(s)} + CO_{2(g)} \Leftrightarrow 2CO_{(g)}$, the equilibrium pressure is $6.75 atm$. If 50% of CO_2 reacts, then find the value of K_p.

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10. At $340K$ and 1 atm pressure, N_2O_4 is 66% into NO_2. What volume of $10gN_2O_4$ ocuupy under these conditions?

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11. Ammonium carbamate when heated to $473K$ gives a mixture of NH_3 and CO_2 vapour with a density of 13. Find the degree of dissociation of ammonium carbamate.

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12. In an experiment starting with 1 mol C_2H_5OH, 1 mol CH_3COOH, and 1 mol of water, the equilibrium mixture mixture of analysis showa that 54.3% of the acid is eaterified. Calculate K_c.

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Comprehension

1. For a reaction, $aA + bB \Leftrightarrow cC + dD$, the reaction quotient $Q = \dfrac{[C]_0^c[D]_0^d}{[A]_0^a[B]_0^b}$, where $[A]_0$, $[B]_0$, $[C]_0$, $[D]_0$ are initial concentrations. Also $K_c = \dfrac{[C]^c[D]^d}{[A]^a[B]^b}$ where $[A]$, $[B]$, $[C]$, $[D]$ are equilibrium concentrations. The reaction proceeds in forward direction if $Q < K_c$ and in backward direction if $Q > K_c$. The variation of K_c with temperature is given by: $2303\dfrac{\log(K_{C_2})}{K_{C_1}} = \dfrac{\Delta H}{R}\left[\dfrac{T_2 - T_1}{T_1T_2}\right]$. For gaseous phase reactions $K_p = K_c(RT)^{\Delta n}$ where $\Delta n =$ moles of gaseous products $-$ moles of gaseous reactants. Also $-\Delta G^\circ = 2.303RT\log_{10}K_c$.

(A) A hydrated salt show efflorescent nature by lossing water molecule . Under what pressure of moisture in atmosphere, $CuSO_4 \cdot 5H_2O$ will show efflorescence bature if

$CuSO_4 \cdot 5H_2O_{(s)} \Leftrightarrow CuSO_4 \cdot 3H_2O + 2H_2O_{(v)}$, $K_p = 62.72mm^2$?

A. $P'_{H_2O} > 62.72mm$

B. $P'_{H_2O} < 62.72mm$

C. $P'_{H_2O} < 7.92mm$

D. $P'_{H_2O} > 7.92mm$

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2. For a reaction, $aA + bB \Leftrightarrow cC + dD$, the reaction quotient $Q = \frac{[C]_0^c[D]_0^d}{[A]_0^a[B]_0^b}$, where $[A]_0$, $[B]_0$, $[C]_0$, $[D]_0$ are initial concentrations. Also $K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$ where $[A]$, $[B]$, $[C]$, $[D]$ are equilibrium concentrations. The reaction proceeds in forward direction if $Q < K_c$ and in backward direction if $Q > K_c$. The variation of K_c with temperature is given by: $2303\frac{\log(K_{C_2})}{K_{C_1}} = \frac{\Delta H}{R}\left[\frac{T_2 - T_1}{T_1T_2}\right]$.

For gaseous phase reactions $K_p = K_c(RT)^{\Delta n}$ where $\Delta n =$ moles of gaseous products $-$ moles of gaseous reactants. Also $-\Delta G^\circ = 2.303RT\log_{10}K_c$.

(B) The moisture content of a gas is often expressed as dew point, the temperature at which if gas is cooled becomes saturted with vapour pressure of water at that temperture. Dew point of H_2O is $43^\circ C$ having vapour pressure 0.07torr.

$CaCl_2 \cdot 2H_2O_{(s)} \Leftrightarrow CaCl_{2(s)} + 2H_2O_{(g)}$,

The equilibrium constant should not be more than..... $(atm)^2$ if $CaCl_2$ is to be used as desiccant.

A. 8.5×10^{-9}

B. 8.5

C. 8.5×10^{-3}

D. 4.9×10^{-3}

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3. For a reaction, $aA + bB \Leftrightarrow cC + dD$, the reaction quotient $Q = \dfrac{[C]_0^c[D]_0^d}{[A]_0^a[B]_0^b}$, where $[A]_0$, $[B]_0$, $[C]_0$, $[D]_0$ are initial concentrations.

Also $K_c = \dfrac{[C]^c[D]^d}{[A]^a[B]^b}$ where $[A]$, $[B]$, $[C]$, $[D]$ are equilibrium concentrations. The reaction proceeds in forward direction if $Q < K_c$

and in backward direction if $Q > K_c$. The variation of K_c with temperature is given by: $2303\frac{\log(K_{C_2})}{K_{C_1}} = \frac{\Delta H}{R}\left[\frac{T_2 - T_1}{T_1 T_2}\right]$.

For gaseous phase reactions $K_p = K_c(RT)^{\Delta n}$ where $\Delta n =$ moles of gaseous products $-$ moles of gaseous reactants. Also $-\Delta G^\circ = 2.303RT\log_{10} K_c$.

The equilibrium constants for the reaction, $CaC_{2(s)} + 5O_{2(g)} \Leftrightarrow 2CaCO_{3(s)} + 2CO_{2(g)}$ is//are given by:

A. $K_c = \frac{[CO_2]^2}{[O_2]^5}$

B. $K_p = \frac{(n_{CO_2})^2}{(n_{O_2})^5} \times \left[\frac{P}{\sum n}\right]^{-3}$

C. $K_p = \frac{(p_{CO_2})^2}{(P_{O_2})^5}$

D. either of these

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4. The relation between K_p and K_c is $K_p = K_c(RT)^{\Delta n}$ unit of $K_p = (atm)^{\Delta n}$, unit of $K_c = \left(molL^{-1}\right)^{\Delta n}$

The equilibrium constant of the following reactions at $400K$ are given:

$2H_2O(g) \Leftrightarrow 2H_2(g) + O_2(g), K_1 = 3.0 \times 10^{-13}$

$2CO_2(g) \Leftrightarrow 2CO(g) + O_2(g), K_2 = 2 \times 10^{-12}$

Then, the equilibrium constant K for the reaction

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

is

A. 2.58

B. 0.066

C. 15

D. 0.38

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5. For a reaction, $aA + bB \Leftrightarrow cC + dD$, the reaction quotient $Q = \frac{[C]_0^c[D]_0^d}{[A]_0^a[B]_0^b}$, where $[A]_0$, $[B]_0$, $[C]_0$, $[D]_0$ are initial concentrations.

Also $K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$ where $[A]$, $[B]$, $[C]$, $[D]$ are equilibrium concentrations. The reaction proceeds in forward direction if $Q < K_c$ and in backward direction if $Q > K_c$. The variation of K_c with temperature is given by: $2303 \frac{\log(K_{C_2})}{K_{C_1}} = \frac{\Delta H}{R}\left[\frac{T_2 - T_1}{T_1 T_2}\right]$.

For gaseous phase reactions $K_p = K_c(RT)^{\Delta n}$ where $\Delta n =$ moles of gaseous products $-$ moles of gaseous reactants. Also $-\Delta G^{\circ} = 2.303 RT \log_{10} K_c$.

The equilibrium constant K_c for $A_{(g)} \Leftrightarrow B_{(g)}$ is 1.1. The gas having concentration ≥ 1 is:

A. $[B]$ if $[A] = 0.91$

B. $[B]$ if $0.9 < [A] \leq 1$

C. both $[A]$ and $[B]$ if $[A] > 1$

D. all are correct

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6. For a reaction, $aA + bB \Leftrightarrow cC + dD$, the reaction quotient $Q = \frac{[C]_0^c [D]_0^d}{[A]_0^a [B]_0^b}$, where $[A]_0$, $[B]_0$, $[C]_0$, $[D]_0$ are initial concentrations.

Also $K_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}$ where $[A]$, $[B]$, $[C]$, $[D]$ are equilibrium concentrations. The reaction proceeds in forward direction if $Q < K_c$ and in backward direction if $Q > K_c$. The variation of K_c with temperature is given by: $2303 \frac{\log(K_{C_2})}{K_{C_1}} = \frac{\Delta H}{R}\left[\frac{T_2 - T_1}{T_1 T_2}\right]$.

For gaseous phase reactions $K_p = K_c(RT)^{\Delta n}$ where $\Delta n =$ moles of gaseous products $-$ moles of gaseous reactants. Also $-\Delta G^\circ = 2.303RT \log_{10} K_c$.

Which relation is correct?

A. $2.303 \log_{10} K = -\frac{\Delta H^\circ}{RT} + \frac{\Delta S^\circ}{R}$

B. $\Delta G = \Delta G^\circ + 2.303RT \log_{10} Q$

C. $K = Ae^{-\Delta H^\circ / RT}$

D. all are correct

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7. For a reaction, $aA + bB \Leftrightarrow cC + dD$, the reaction quotient $Q = \frac{[C]_0^c[D]_0^d}{[A]_0^a[B]_0^b}$, where $[A]_0$, $[B]_0$, $[C]_0$, $[D]_0$ are initial concentrations.

Also $K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$ where $[A]$, $[B]$, $[C]$, $[D]$ are equilibrium concentrations. The reaction proceeds in forward direction if $Q < K_c$ and in backward direction if $Q > K_c$. The variation of K_c with temperature is given by: $2303\frac{\log(K_{C_2})}{K_{C_1}} = \frac{\Delta H}{R}\left[\frac{T_2 - T_1}{T_1T_2}\right]$.

For gaseous phase reactions $K_p = K_c(RT)^{\Delta n}$ where $\Delta n =$ moles of gaseous products $-$ moles of gaseous reactants. Also $-\Delta G^\circ = 2.303RT\log_{10}K_c$.

The heat or reaction for an endothermic reaction, in equilibrium is $1200cal$, at constant volume is more than at constant pressure at $300K$. The ratio of K_p / K_c is:

A. 1.648×10^{-3}

B. 16.48×10^{-3}

C. 606.6

D. 60.66

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8. Influence of pressure, temperature, concentration and addition of inert gas on a reversible chemical reaction in equilibrium can be explained by formulating the expression for equilibrium constant K_c or K_p for the equilibrium. On the other hand Le Chatelier principle can be theoretically used to explain the effect of P, T or concentration on the physical or chemical equilibrium both.

For a reversible reaction:

$2NO_{(g)} + O_{2(g)} \Leftrightarrow 2NO_{2(g)}$

the rate expression is given as $\left(\frac{dx}{dt}\right)_{\text{net}} = 2.6 \times 10^3 [NO]^2 [O_2] - 4.1 [NO_2]^2$. The equilibrium constant of reaction is:

A. 1.58×10^{-3}

B. 634.15

C. 10.66×10^3

D. 1.06×10^3

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9. Influence of pressure, temperature, concentration and addition of inert gas on a reversible chemical reaction in equilibrium can be explained by formulating the expression for equilibrium constant K_c or K_p for the equilibrium. On the other hand Le Chatelier principle can be theoretically used to explain the effect of P, T or concentration on the physical or chemical equilibrium both.

For the reaction : $PCl_5 \Leftrightarrow PCl_3 + Cl_2$, increase of pressure shows.

A. An increase in degree of dissociation and a decrease in K_c

B. A decrease in degree of dissociation and a decrease in K_c

C. An increase in degree of dissociation but K_c remains constant

D. A decrease in degree of dissociation but K_c remains constant.

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10. Influence of pressure, temperature, concentration and addition of inert gas on a reversible chemical reaction in equilibrium can be explained by formulating the expression for equilibrium constant K_c or K_p for the equilibrium. On the other hand Le Chatelier principle can be theoretically used to explain the effect of P, T or concentration on the physical or chemical equilibrium both.

For the reaction: $2SO_2 + O_2 \Leftrightarrow 2SO_3, \Delta H = -ve.$

An increase in temperature shows:

A. more dissociation of SO_3 and a decrease in K_c

B. less dissociation of SO_3 and an increase in K_c

C. more dissociation of SO_3 and an increase in K_c

D. less dissociation of SO_3 and a decrease in K_c

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11. Influence of pressure, temperature, concentration and addition of inert gas on a reversible chemical reaction in equilibrium can be explained by formulating the expression for equilibrium constant K_c or K_p for the equilibrium. On the other hand Le Chatelier principle can be theoretically used to explain the effect of P, T or concentration on the physical or chemical equilibrium both.

For the reaction:

$$\underset{Yellow}{Fe^{3+}_{(aq.)}} + SCN^{-}_{(aq.)} \Leftrightarrow \underset{Red}{[Fe(NCS)]^{2+}_{(aq.)}}$$

in equilibrium if little more aqueous solution in $FeCl_3$ is added, then:

A. forward reaction becomes more and red colour is deepened

B. backward reaction becomes more and red colour faintens

C. solution becomes colourless

D. none of these

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12. Influence of pressure, temperature, concentration and addition of inert gas on a reversible chemical reaction in equilibrium can be explained by formulating the expression for equilibrium constant K_c or K_p for the equilibrium. On the other hand Le Chatelier principle can be theoretically used to explain the effect of P, T or concentration on the physical or chemical equilibrium both.

n moles of a reactant A gives one mole of B and C. If degree of dissociation of A is independent of initial concentration of A, then n is:

A. 1

B. 2

C. 3

D. 4

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13. Influence of pressure, temperature, concentration and addition of inert gas on a reversible chemical reaction in equilibrium can be explained by formulating the expression for equilibrium constant K_c or K_p for the equilibrium. On the other hand Le Chatelier principle can be theoretically used to explain the effect of P, T or concentration on the physical or chemical equilibrium both.

N_2O_4 is 66% dissociated into NO_2 at $340K$ and 1 atmospheric pressure. The volume occupied by $10gN_2O_4$ under these conditions is:

A. $5.03 litre$

B. $10.04 litre$

C. $2.58 litre$

D. $3.24 litre$

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14. A given sample of N_2O_4 in a closed vessel shows 20% dissociation in NO_2 at $27^\circ C$ and 760torr. The sample is now heated upto $127^\circ C$ and the analysis of mixture shows 60% dissociation at $127^\circ C$.

The total pressure of equilibrium mixture (in atm) at $127^\circ C$ is :

A. $1.78atm$

B. $2.01atm$

C. $3.18atm$

D. $1.33atm$

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15. A given sample of N_2O_4 in a closed vessel shows 20% dissociation in NO_2 at $27^\circ C$ and 760torr. The sample is now heated upto $127^\circ C$ and the analysis of mixture shows 60% dissociation at $127^\circ C$.

The molecular weight of mixture at $27^\circ C$ is :

A. 76.66

B. 78.69

C. 66.52

D. 80.24

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16. A given sample of N_2O_4 in a closed vessel shows 20% dissociation in NO_2 at $27^\circ C$ and 760torr. The sample is now heated upto $127^\circ C$ and the analysis of mixture shows 60% dissociation at $127^\circ C$.

The equilibrium constant (K_p) for the decomposition of N_2O_4 at $27^\circ C$ is :

A. 0.165

B. 0.29

C. 0.523

D. 0.25

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17. A given sample of N_2O_4 in a closed vessel shows 20% dissociation in NO_2 at $27^{\circ}C$ and 760torr. The sample is now heated upto $127^{\circ}C$ and the analysis of mixture shows 60% dissociation at $127^{\circ}C$.

The equilibrium constant (K_c) for decomposition of N_2O_4 at $127^{\circ}C$:

A. 0.30

B. 0.12

C. 0.40

D. 0.25

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18. A given sample of N_2O_4 in a closed vessel shows 20% dissociation in NO_2 at $27^\circ C$ and 760torr. The sample is now heated upto $127^\circ C$ and the analysis of mixture shows 60% dissociation at $127^\circ C$.

The density of the equilibrium mixture (in $g/litre$) at $27^\circ C$ is :

A. 3.1

B. 4.2

C. 2.1

D. 3.7

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19. A given sample of N_2O_4 in a closed vessel shows 20% dissociation in NO_2 at $27^\circ C$ and 760torr. The sample is now heated upto $127^\circ C$ and the analysis of mixture shows 60% dissociation at $127^\circ C$.

The heat of dissociation of N_2O_4 (in $kcal mol^{-1}$) in this temperature range is :

A. 9.77

B. 7.66

C. 10.80

D. 11.40

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20. The $N_2O_4 / NO_{2(g)}$ equilibrium is endothermic as shown below:

$$\underset{Colourles}{N_2O_{4(g)}} \Leftrightarrow \underset{Darkbrown}{2NO_{2(g)}}, (\Delta H = +ve)$$

The equilibrium is attained in a container having movable piston by taking $1 mole$ of $N_2O_{4(g)}$ at $50^\circ C$ and $1 atm$ pressure. At equilibrium, relative molecular mass of the mixture is 65.7.

The degree of dissociation of N_2O_4 at equilibrium is:

A. 0.4

B. 0.04

C. 0.03

D. 0.2

Answer: A

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21. The $N_2O_4/NO_{2(g)}$ equilibrium is endothermic as shown below:

$$\underset{Colourles}{N_2O_{4(g)}} \Leftrightarrow \underset{Darkbrown}{2NO_{2(g)}}, (\Delta H = +ve)$$

The equilibrium is attained in a container having movable piston by taking $1 mole$ of $N_2O_{4(g)}$ at $50^\circ C$ and $1 atm$ pressure. At equilibrium, relative molecular mass of the mixture is 65.7.

The equilibrium constant for the given reaction is:

A. $2.9 moldm^3$

B. $0.29 moldm^3$

C. $0.029 moldm^3$

D. $0.0029 moldm^3$

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22. The $N_2O_4/NO_{2(g)}$ equilibrium is endothermic as shown below:

$$\underset{Colourles}{N_2O_{4(g)}} \Leftrightarrow \underset{Darkbrown}{2NO_{2(g)}}, (\Delta H = +ve)$$

The equilibrium is attained in a container having movable piston by taking $1mole$ of $N_2O_{4(g)}$ at $50^\circ C$ and $1atm$ pressure. At equilibrium, relative molecular mass of the mixture is 65.7.

If pressure on the mixture is increased, such that volume of mixture becomes half of I equilibrium, then:

A. $K_c = 0.029$ and $\alpha = 0.4$

B. $K_c = 0.029$ and $\alpha = 0.30$

C. $K_c = 0.015$ and $\alpha = 0.3$

D. $K_c = 0.015$ and $\alpha = 0.40$

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Statement:Explanation

1. Assertion: Water boils at higher temperature in pressure cooker.

Reason: Increase in pressure leads to an increase in boiling temperature.

A. S is correct but E is wrong.

B. S is wrong but E is correct.

C. Both S and E are correct and E is correct explanation of S.

D. Both S and E are correct but E is not correct explanation of S.

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2. Assertion: Snow does not melt easily at mountains.

Reason: A decrease in pressure leads to an increase in freezing point.

A. S is correct but E is wrong.

B. S is wrong but E is correct.

C. Both S and E are correct and E is correct explanation of S.

D. Both S and E are correct but E is not correct explanation of S.

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3. Assertion: The solubility of gases always increases with increase in pressure.

Reason: High pressure favours the change where volume decreases.

A. S is correct but E is wrong.

B. S is wrong but E is correct.

C. Both S and E are correct and E is correct explanation of S.

D. Both S and E are correct but E is not correct explanation of S.

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4. Assertion: The melting point of solid (except ice) increases with increase in pressure.

Reason: An increase in pressure favours the change where volume decreases.

A. S is correct but E is wrong.

B. S is wrong but E is correct.

C. Both S and E are correct and E is correct explanation of S.

D. Both S and E are correct but E is not correct explanation of S.

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5. Assertion: Association of an inert gas at constant pressure to dissociation equilibrium of $PC1_5 \Leftrightarrow PC1_3 + C1_2$ favours forward reaction.

Reason: $K_c = \dfrac{\alpha^2}{V(1-\alpha)}$ for the dissociation equilibrium of $PC1_5$ where α is degree of dissociation of $PC1_5$.

A. S is correct but E is wrong.

B. S is wrong but E is correct.

C. Both S and E are correct and E is correct explanation of S.

D. Both S and E are correct but E is not correct explanation of S.

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6. Assertion: $\Delta G = \Delta G^{\circ}$ + 2.303 RT log Q, where Q is reaction quotient.

Reason: Q may be greater or lesser than K_c but equal to K_c if $\Delta G = 0$.

A. S is correct but E is wrong.

B. S is wrong but E is correct.

C. Both S and E are correct and E is correct explanation of S.

D. Both S and E are correct but E is not correct explanation of S.

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7. Statement: The equilibrium constant K_c or K_p has the unit $(\text{mole} litre^{-1})^{\Delta n}$ or $(atm)^{\Delta n}$ respectively.

Explanation: The numerical value of $K_c = K_p$ at $\Delta n = 0$.

A. S is correct but E is wrong.

B. S is wrong but E is correct.

C. Both S and E are correct and E is correct explanation of S.

D. Both S and E are correct but E is not correct explanation of S.

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8. Assertion (A) : A catalyst does not influences the values of equilibrium constant

Reason (R) : Catalyst influences the rate of both forward and backward reactions equally.

A. S is correct but E is wrong.

B. S is wrong but E is correct.

C. Both S and E are correct and E is correct explanation of S.

D. Both S and E are correct but E is not correct explanation of S.

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9. High pressure and low temperature are favourable conditions for the synthesis of ammonia.

A. S is correct but E is wrong.

B. S is wrong but E is correct.

C. Both S and E are correct and E is correct explanation of S.

D. Both S and E are correct but E is not correct explanation of S.

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10. Assertion: The equilibrium constant may show higher or lower values with increase in temperature.

Reason: The change depends on the heat of reaction at equilibrium.

A. S is correct but E is wrong.

B. S is wrong but E is correct.

C. Both S and E are correct and E is correct explanation of S.

D. Both S and E are correct but E is not correct explanation of S.

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11. Statement: The equilibrium constant for a reaction having positive ΔH° increases with increase of temperature.

Explanation: The temperature dependence of the equilibrium constant is related to ΔH° and not ΔS° for the reaction.

A. S is correct but E is wrong.

B. S is wrong but E is correct.

C. Both S and E are correct and E is correct explanation of S.

D. Both S and E are correct but E is not correct explanation of S.

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12. Statement: Concentration of the reactant and product does not change with time at equilibrium for a chemical reaction.

Explanation: The rate of a reaction is zero at equilibrium.

A. S is correct but E is wrong.

B. S is wrong but E is correct.

C. Both S and E are correct and E is correct explanation of S.

D. Both S and E are correct but E is not correct explanation of S.

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13. Statement: The reaction: $2NO_{(g)} + O_{2(g)} \Leftrightarrow 2NO_2$ is favoured in the forward direction with increase of pressure.

Explanation: The reaction is exothermic.

A. S is correct but E is wrong.

B. S is wrong but E is correct.

C. Both S and E are correct and E is correct explanation of S.

D. Both S and E are correct but E is not correct explanation of S.

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