CHEMISTRY

JEE (MAIN AND ADVANCED) CHEMISTRY

CHEMICAL EQUILIBRIUM

Problem

1. The reaction between ethanoic acid and ethanol is reversible even in an open vessel.Why?

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2. How is the establishment of water and water vapour equilibrium detected?

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3. Solubility of iodine of water is $1.1 \times 10^{-3} molL^{-1}$ at 290K. When 0.1g of iodine is stirred in 200ml water till the equilibrium is reached at 290K, calculate the mass of undissolved iodine.

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4. Chemical equilibrium is dynamic. Why?

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5. 4.25 grams of ammonia are dissolved to form 4L aqueous solution. Calculate the active mass.

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6. What is the active mass of one litre of oxygen gas at NTP?

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7. PCl_5 was taken at 2 atm in a closed vessel at $154^\circ C$ Keeping the temperature constant $PCl_5 \leftrightarrow PCl_3 + Cl_2$ equilibrium is established when 50% of PCl_5 decomposes. Calculate the K_p for the equilibrium.

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8. Equilibrium constant K_c for the reaction $H_2(g) + I_2(g) \leftrightarrow HI_{(g)}$ is 50. What is the value of K_c for the reaction $\frac{1}{2}H_2(g) + \frac{1}{2}I_2(g) \leftrightarrow HI$ and $2HI(g) \leftrightarrow H_2(g) + I_2(g)$?

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9. K_c values respectively for the reactions, $H_2SO_3 \leftrightarrow H^+ + HSO_3^-$ and $HSO_3^- \leftrightarrow H^+ + SO_3^{2-}$ and 2×10^{-2} and Calculate the K_c for the reaction $H_2SO_3 \leftrightarrow 2H^+ + SO_3^{2-}$

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10. The reaction was started with 0.1M each of CO and H_2O at 800K. K_c for the chemical reaction , $CO(g) + H_2O(g) \leftrightarrow CO_2(g) + H_2(g)$ at 800K is 4.24.Calculate the equilibrium concentration of the lightest gas.

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11. K_p for the reaction $NH_4HS(s) \leftrightarrow NH_3(g) + H_2S(g)$ at certain temperature is $9 \overline{\frown} 2$ Calculate the equilibrium pressure.

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12. For the cyclic teimerisation of acetylene to give one mole of benzene $K_c = 4L^2mol^{-2}$ IF the equilibrium concentration of benzene is $0.5molL^{-1}$ calculate the equilibrium concentration of acetylene.

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13. At 500K, $K_p = 1.8 \times 10^{-2}$ atm for the reaction $2NOCL(g) \leftrightarrow 2NO_{(g)} + CL_2(g)$ calculate the K_C at the same temperature.

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14. For the equilibrium $2SO_3(g) \leftrightarrow 2SO_2(g) + O_2(g)$ the partial pressure SO_3, SO_2 and O_2 gases , at 650 K are respectively 0.3 bar ,0.6 bar and 0.4 bar. IF the moles of both the oxides of sulphur are so adjusted as equal, what will be the partial pressure of O_2.

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15. The equilibrium constant for the reaction $2X + Y \leftrightarrow X_2Y$ is $10L^2mol^{-2}$. The rate constant for the backward reaction $28s^{-1}$. What is the rate constant of the forward reaction.

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16. K_C for the reaction $2X \leftrightarrow Y + Z$ is 2×10^{-3} at a given time the composition of reaction mixture $[X] = [Y] = [Z] = 2.8 \times 10^{-4} M$. IN what direction, the reaction will proceed?

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17. $N_2O_4(g) + 57KJ \leftrightarrow 2NO_2(g)$. Predict favourable Le chaterlier conditions.

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18. Solubility of NH_4Cl increases, while that of $CaCl_2$ decreases upon heating why?

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19. Formation of NH_4 is preferred at low temperature, whereas formation of NO requires high temperature. Why?

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20. What is the effect of added sodium thiocyanate on the following equilibrium?

$Fe^{3+}(aq) + SCN^{-}(aq) \leftrightarrow [FeSCN]^{2} + (aq)$

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21. At room temperature the following equilibrium mixture is blue but when cooled in a freezing mixture, the colour of mixture turns pink. What is the nature of reaction.

$\left[Co(H_2O)_6\right]_{aq}^{2+} + 4Cl^{-} \leftrightarrow [CoCl_4]_{aq}^{2-} + 6H_2O(l)$

Pink Blue

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22. What is the effect of increase of pressure on the following physical equilibrium?

$H_2O(s) \leftrightarrow H_2O(l)$

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23. What is the effect of addition of oxalic acid and $HgCl_2$ to the following equilibrium

$F_{aq}^{3+} + SCN_{aq}^{-} \leftrightarrow [Fe(SCN)]_{aq}^{2+}$

Yellow Colourless Deepred

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Exercise 11

1. What are irreversible reactions. Give examples.

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2. Give examples of reversible reactions.

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3. Describe the equilibrium state and its attainment.

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4. Write the important characteristics of equilibrium.

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5. What are homogenous and heterogenous equilibria? Give two example of each .

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Exercise 1 2

1. State and explain law of mass action.

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2. Write the expression for the equilibrium constant for the reaction $2A + B \leftrightarrow C + D$

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3. With suitable examples, discuss the relationship between K_c and K_p.

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4. Write the characteristics of equilibrium constant.

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5. At equilibrium $AB_5(g) \leftrightarrow AB_3(g) + B_2(g)$ the concentrations of AB_5 and AB_3 are 0.2 and 0.1 $molL^{-1}$ respectively. If $K_c = 0.5molL^{-1}$ calculate the equilibrium concentration of B_2.

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6. $PCl_5(g) \leftrightarrow PCl_3(g) + Cl_2(g)$ At 300K, K_C is $0.204molL^{-1}$. What is the value of K_p?

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7. $13.8g$ of N_2O_4 was placed in a $1L$ reaction vessel at $400K$ and allowed to attain equilibrium

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

The total pressure at equilibrium was found to be 9.15 bar . Calcualate K_c , K_p and partial pressure at equilibrium.

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8. 3.00 mol of PCl_5 kept in $1L$ closed reaction vessel was allowed to attain equilibrium at $380K$. Calculate composition of the mixture at equlibrium $K_c = 1.80$

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9. K_p for the reaction $2SO_3(g) + O_2(g) \leftrightarrow 2SO_3(g)$ is $2.5 \times 10^{20} atm^{-1}$ at 500K. Calculate the K_p for the reaction $SO_3(g) \leftrightarrow SO_2(g) + \frac{1}{2}O_2(g)$.

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10. At 1300K, 0.3 mol of CO ,0.1 mol H_2, 0.02 mol of H_2O and an unknown amount of CH_4 are present at equilibrium in a vessel. K_c for the reaction $CO_g + H_2(g) \leftrightarrow CH_4(g) + H_2O(g)$ is 3.9. What is the equilibrium concentration CH_4

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11. 0.482 mol N_2 and 0.933 mol O_2 are placed in a 10 L vessel and allowed to form N_2O at constant temperature. Numerical value of K_c for the reaction $2N_2(g) + O_2(g) \leftrightarrow 2N_2O(g)$ is $2 \times 10^{-37} Kmol^{-1}$. Calculate the equilibrium concentration of nirous oxide.

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12. The degree of dissociation of phosphorous pentachloride at certain temperature at 1atm is 0.2. calculate the pressure at which phosphorous pentachloride will be half dissociated at the same temperature.

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13. K_c for the reaction $H_2 + I_2 \leftrightarrow 2HI$ at $500^\circ C$ is 45.9. calculate the equilibrium concentration of HI.

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Exercise 1 3

1. Explain Le Chatelier's principle.

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2. What are the Le chatelier predictions on the influence of change of pressure, temperature and concentration on equilibria?

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3. What is the effect of addtion of $NaNO_2$ to the decomposition of $NaNO_3$.

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Questions For Descriptive Answers

1. The characteristic of equilibrium and equilibrium constant are different. Explain.

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2. Is evaporation of water a reversible process?

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3. A dynamic equilibrium means a balance between the tendency towards minimum and maximum enthalpes. Explain.

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4. Write the expression for the equilibrium constant of the reversible reaction.

$2ClO_2(g) \leftrightarrow Cl_2(g) + 2O_2(g)$

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5. Starting from one mole each of anol and acetic acid, at equilibrium $2/3$ mole of ester is formed . Calculate the equilibrium constant.

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6. At $8.2^{\circ}C$, $0.778 moldm^{-3}$ of N_2O_4 and $2.84 \times 10^{-3} moldm^{-3}$ of NO_2 were observed in certain experiment in a chloroform solution. Calculate the value of equilibrium constant for the reaction, $2NO_2(g) \leftrightarrow N_2O_4(g)$.

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7. At an equilibrium pressure of 2atm, the K_p for the reaction $PCl_5(g) \leftrightarrow PCl_3(g) + Cl_2(g)$ is 1.286 atm. What is the extent of dissociation of PCl_5.

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8. At $125^{\circ}C$ the K_p for the reaction $N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g)$ is $2.15 \times 10^{-6} atm^{-2}$. Calculate K_c for the equilibrium at same temperature.

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9. For the reaction $H_2(g) + Br_2(g) \leftrightarrow 2HBr(g)$ at 1024K, K_p is 1.6×10^5. IF 10 bar of hydrogen bromide is introduced into the vessel at 1024K to establish equilibrium, what is the equilibrium pressure of hydrogen bromide?

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

$C(s) + CO_2(g) \Leftrightarrow 2CO(g)$

Calculate K_c for this reaction at the above temperature.

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11. Some solid NH_4HS is placed in a flask containing 0.5 atm NH_3. What is the equilibrium presence of NH_3 if $K_p = 0.11atm^2$ for the reaction $NH_4HS(s) \leftrightarrow NH_3(s) + H_2S(g)$.

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12. K_c is 6.3×10^{14} for the reaction $NO + O_3 \leftrightarrow NO_2 + O_2$ at 1000K, calculate K_c for the reverse reaction.

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13. The equilibrium constant K_c for the $SO_{2(g)} + NO_{2(g)} \Leftrightarrow SO_{3(g)} + NO_{(g)}$ reaction is 16. if 1 mole of each of all the four gases is taken in ldm^3 vessel, the equilibrium concentration of NO would be

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14. An equilibrium mixture $N_2O_4 \leftrightarrow 2NO_2$ at 300K contains N_2O_4 and NO_2 at 0.28 and 1.1 atm, respectively. IF the volume of the container is doubled. Calculate the equilibrium pressure of nitrogen dioxide.

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15. K_c for the reaction $H_2 + I_2 \leftrightarrow 2HI$ at $500^\circ C$ is 45.9. calculate the equilibrium concentration of HI.

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16. The equilibrium constant for the polymerisation of formaldehyde to glucose is aqueous solution is 6×10^{22}. IF 1M glucose is at equilibrium $6HCHO \leftrightarrow C_6H_{12}O_6$ what is the concentration of formaldehyde at equilibrium?

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17. K_C for the reaction $N_2 + O_2 \leftrightarrow 2NO$ in air at 2500K is 2.1×10^{-3}. At equilibrium mole percentage of nitric oxide is 1.8. What is the mole fraction of N_2 in the air.

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18. The degree of dissociation is 0.4 at 400 K and a I atm for the gaseous reaction: $PCI_{5(g)} \Leftrightarrow PCl_{3(g)} + Cl_{2(g)}$: assuming ideal behaviour of gases, calculate the density of cquilibrium mixture at 400K and latm

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19. 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 $3.3 \times 10^{-3} molL^{-1}$, what is its molar concentration in the mixture at equilibrium?

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20. Calculate the extent of dissociation of PCl_5 if the equilibrium pressure is numerically 3 times of its K_p.

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21. K_p for the reaction $N_2O_4(g) \leftrightarrow 2NO_2(g)$ at 750K is 640torr. Calculate the percentage of dissociation of N_2O_4 at equilibrium pressure of 160torr.

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22. At 1065° C the heat of dissociation of H_2S is 42.4K cal and the K_p for the decomposition reaction $2H_2S \leftrightarrow 2H_2 + S_2$ is 0.0118 atm. Find the K_p at $1132^\circ C$

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23. K_c for the reaction $Ag(CN)_2^- \leftrightarrow Ag^+ + 2CN^-$ at 298K is $4 \times 10^{-19} M^2$. Starting with 0.1M KCN and 0.03 $AgNO_3$. Calculate the equilibrium concentration of Ag^+

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24. $2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g)$ IF the volume of reaction vessel is increased, what happens to Kc. Explain.

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25. Ice melts slowly at high altitudes. Explain Why?

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26. Water boils at high temperature, taken in a pressure cooker. Explain?

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27. K_C for the reaction $2X \leftrightarrow Y + Z$ is 2×10^{-3} at a given time the composition of reaction mixture $[X] = [Y] = [Z] = 2.8 \times 10^{-4} M$. IN what direction, the reaction will proceed?

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28. On a red hot coke carbondioxide is reduced to carbon monoxide. Write the equation and predict the favourable conditions for the reactions.

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29. The specific heat capacity of a gas at constant pressure is greater than that at constant volume because

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30. $N_2(g) + O_2(g) + 181kJ \leftrightarrow 2NO(g)$ Write the Le Chatelier's conditions for shifting the equilibrium towards the formation of nitric acid.

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