PREVIOUS HSE QUESTIONS FROM THE CHAPTER "*EQUILIBRIUM*"

1. What are Buffer Solutions? Give an example. (2)
2. (i) What is a conjugate acid-base pair ? (1)
   (ii) Write the conjugate acid of the base H_2O. (1)
3. (i) State Le Chatelier's principle. (1)
   (ii) What are the effects of the following changes in the equilibrium process?
   $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$; $\Delta H = -92.38$ kJ/mol.
   (A) Increasing the pressure
   (B) Increasing the temperature
   (C) Removal of NH_3 from the reaction vessel. (3)
4. (i) Define the term pH. (1)
   (ii) The concentration of H^+ ion in a soft drink is 3×10^{-12} M. Calculate its pH. Identify whether the solution is acidic or basic. (3) [December 2021]
5. Write expression for equilibrium constant (Kc) for the following reactions :
   (a) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
   (b) $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$
6. What are buffer solutions? Give an example for buffer solution.
7. (i) Predict the effect of change of pressure in the following equilibrium :
   $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ (2)
   (ii) Name and state the law used to predict effect of change in pressure in an equilibrium. (2)
8. (i) Write Arrhenius concept of Acids and Bases. (2)
   (ii) Write conjugate acid and conjugate base of the following:
   (a) H_2O (b) NH_3 (2) [September 2021]
9. An example of Lewis acid among the following is:
   (A) HCl (B) NH_3 (C) H_2SO_4 (D) BF_3 (1)
10. (a) Write the expression for the equilibrium constant of the general reaction: $aA + bB \rightleftharpoons cC + dD$. (1)
    (b) Give the relation between Kp and Kc of a reaction in equilibrium. (1)
11. (a) What is ionic product of water? (1)
    (b) Arrange the following in the increasing order of their acidic strength: HBr, HI, HF, HCl (1)
    (c) (i) The dissociation of NH_4OH is suppressed by the addition of NH_4Cl. Name the principle applied here. (1)
    (ii) Give an example for acidic buffer. (1) [December 2020]
12. The species that can form both conjugate acid and conjugate base among the following is:
    (a) H_2O (b) BF_3 (c) HCl (d) CO_2 (1)
13. Derive the relation between equilibrium constants Kc and Kp for a general reaction:
    $aA + bB \rightleftharpoons cC + dD$ at equilibrium. (2)
14. (a) Predict the nature of solution produced by the hydrolysis of sodium acetate. (1)
    (b) Calculate the pH of a solution having H^+ ion concentration 3.8×10^{-3} M. (2)
    (c) Explain the effect of pressure in the following equilibrium using Le Chatelier principle:
    $CO(g) + 3H_2(g) \rightleftharpoons CH_4(g) + H_2O(g)$ (1) [March 2020]
15. (a) If the concentration of hydrogen ion in a soft drink is 3×10^{-3} M, calculate its pH. (2)
    (b) An aqueous solution of NaCl is neutral, while that of $CuCl_2$ is acidic. Why? (1)

16. For the equilibrium, 2 NOCl (g) $\rightleftharpoons$ 2 NO(g) + Cl_2(g), the value of equilibrium constant Kp is 1.8 x 10^{-2} at 500 K. Calculate Kc for this reaction at the same temperature. (2)
17. Give the Lewis concept of acids and bases with suitable example. (2) [July 2019]
18. Calculate the pH of 1 x 10^{-2} molar aqueous solution of H_2SO_4. (2)
19. Examine the chemical equilibrium, 4 NH_3(g) + 5 O_2(g) $\rightleftharpoons$ 4 NO(g) + 6 H_2O(l).
    Write the expression for equilibrium constant (Kc) for the above equilibrium. What happens to Kc, if the balanced equation is multiplied throughout by a factor of 2. (2)
20. Explain the hydrolysis of different types of salts with the help of examples and comment on the pH of the resulting solutions in each case. (3) [March 2019]
21. Give the relation between Kp and Kc, for the reaction given below.
    2NOCl (g) $\rightleftharpoons$ 2NO(g) + Cl_2(g) (2)
22. H_2O and HSO_4^- can act both as Bronsted acids and bases. For each case give the corresponding conjugate acid and conjugate base. (2)
23. The ionization constant of nitrous acid is 4.5 x 10^{-4}. Calculate the pH of 0.04 M solution of nitrous acid in water.
    (Hint: HNO_2+ H_2O $\rightleftharpoons$ H_3O^+ + NO_2^-; $K_a = C\alpha^2$) (3) [August 2018]
24. Explain the effects of temperature and pressure on the following equilibrium.
    $2NO_2(g) \rightleftharpoons N_2O_4$ (g) ΔH = -57.2 kJmol $^{-1}$ (2)
25. Define buffer solutions and write one example for an acidic buffer. (2)
26. The value of equilibrium constant is useful to predict the extent of reaction and the direction of the reaction at a given stage. Explain. (3) [March 2018]
27. a) Classify the following into Lewis acid and Lewis base. i) H_2O ii) NH_3 iii) $AlCl_3$ iv) H^+ (1)
    b) Explain the term common ion effect with suitable example. (2)
    c) The concentration of H^+ ion in a soft drink is 2 x 10^{-13}. Calculate its pH. Identify whether the solution is acidic or basic. (2) [July 2017]
28. a) Classify the following solutions into acidic, basic and neutral.
    NaCl, NH_4NO_3, NaCN, $NaNO_2$ (2)
    b) pH of blood remains constant inspite of variety of goods and spices we eat. Give a reason. (1)
    c) The solubility of $Mg(OH)_2$ at 298K is 1.5 x 10^{-4}. Calculate the solubility product. (2) [March 2017]
29. a) The solubility product of salt is related to its solubility.
    i) Give the relation between solubility product and solubility of $BaSO_4$. (1)
    ii) The solubility product of $BaSO_4$ is 1.2 x 10^{-10} at 298K. Calculate the solubility of $BaSO_4$ at 298K. (2)
    b) Differentiate between homogeneous and heterogeneous equilibria. (2) [September 2016]
30. a) Write the expression for equilibrium constant Kc for the following equilibrium.
    $CuSO_4.5H_2O(s) \rightleftharpoons CuSO_4.3H_2O(s) + 2\ H_2O(g)$ (2)
    b) The solubility product of $Al(OH)_3$ is 1 x 10^{-36}. Calculate the solubility of $Al(OH)_3$. (3)
31. a) Explain the concept of Lewis acid and Lewis bases with suitable examples. (3)
    b) Write the Henderson – Hasselbalch equation for an acidic buffer. Calculate the pH of an acidic buffer containing 0.1 M CH_3COOH and 0.5 M CH_3COONa. [Ka for CH_3COOH is 1.8 x 10^{-6}]. (2) [March 2016]
32. Equilibrium constant helps in predicting the direction in which a given reaction will proceed at any stage.
    a) In which one of the following conditions a chemical reaction Proceeds in the forward direction?
       i) $Q_C < K_C$ ii) $Q_C > K_C$ iii) $Q_C = 1/K_C$ IV) $Q_C = - K_C$ (1)
    b) Write whether the following statement is true or false:
       "High value of equilibrium constant suggests high concentration of the reactants in the equilibrium mixture". (1)

c) State the Le-Chatlier's principle. Applying this principle, explain the effect of pressure in the following equilibrium.
$CO(g) + 3\ H_2(g) \rightarrow CH_4(g) + H_2O(g)$ (3) [September 2015]

33. a) i) Give the Arrhenius concept about acids and bases. (1)
ii) Give one example each for Arrhenius acid and base. (1)
b) i) Write the expression for equilibrium constant Kp for the following equilibrium.
$2NOCl_{(g)} \rightleftharpoons 2NO_{(g)} + Cl_{2(g)}$ (1)
ii) Find the value of Kc for the above equilibrium if the value of Kp is 1.8×10^{-2} atm at 600 K.
($R= 0.0821$ Latm $K^{-1}mol^{-1}$) (2) [March 2015]

34. Le-Chatlier's principle makes a qualitative prediction about the change in conditions on equilibrium.
a) State Le-Chatlier's principle. (1)
b) $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$.
What is the effect of pressure on the above equilibrium? (2)
c) The species HCO_3^- and HSO_4^- can act both as Bronsted acids and bases. Write the corresponding conjugate acid and conjugate base of the above species. (2) [August 2014]

35. a) Write an equation for equilibrium constant in terms of concentration (K_c) for the equilibrium reaction given below.
$Ag_2O(s) + 2HNO_3(aq) \rightleftharpoons 2\ AgNO_3(aq) + H_2O(l)$ (1)
b) What are buffer solutions? Give an example for a buffer solution. (2)
c) The concentration of H^+ ion in a sample of soft drink is 3.8×10^{-3}M. Determine its pH. (2) [March 2014]

36. a) What is conjugate acid – base pair? Illustrate with an example. (1)
b) Define the pH scale. The pH of a soft drink is 2.42. Give the nature of the solution. (2)
c) An aqueous solution of $CuSO_4$ is acidic while that of Na_2SO_4 is neutral. Explain. (2) [September 2013]

37. Equilibrium is possible only in a closed system at a given temperature.
a) Write the expression for equilibrium constant, Kc for the reaction
$4\ NH_3(g) + 5\ O_2(g) \rightleftharpoons 4\ NO(g) + 6\ H_2O(l)$ (1)
b) What happens to the value of the equilibrium constant (Kc) when the above reaction is reversed? (1)

38. Weak acids are partially ionized in aqueous solutions.
a) The ionization constants of some acids are given below:

Acid	Ionisation constant (Ka)
Formic acid (HCOOH)	1.8×10^{-4}
Hypochlorous acid (HClO)	3.0×10^{-8}
Nitrous acid (HNO_2)	4.5×10^{-4}
Hydrocyanic acid (HCN)	4.9×10^{-10}

Arrange the above acids in the increasing order of their acid strength. (1)
b) Calculate the pH of a 0.01 M acetic acid solution with the degree of ionization 0.045. (2)

39. Salts can be classified into different categories on the basis of their solubility.
a) Identify the solubility range of sparingly soluble salts from the following:
(Between 0.01 M and 0.1 M, less than 0.01 M, greater than 0.1 M). (1)
b) Calculate the solubility (S) of $CaSO_4$ at 298 K, if its solubility product constant (Ksp) at this temperature is 9×10^{-6}.
(2) [March 2013]

40. a) During a class room discussion one of your friends argues that equilibrium constant is not altered with change in temperature. What is your view towards this argument? Justify. (2)
b) Dissociation of $CaCO_3$ in a closed vessel is given as $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$
i) Write an expression for Kc. (1)
ii) Explain the effect of increase in pressure on the above reaction. Name the principle behind this. (2)
[September 2012]

41. Le-Chatlier's principle helps to explain the effect of change in conditions on equilibrium.

Discuss the effect of pressure in the following equilibrium on the basis of Le-Chatlier's principle:

$CO(g) + 3\ H_2(g) \rightleftharpoons CH_4(g) + H_2O(g)$ (2)

42. The behaviour of acids and bases can be explained by using different concepts.
    a) Select the Lewis acid from the following: (NH_3, OH^-, BCl_3, Cl^-) (1)
    b) What are conjugate acid – base pairs? Illustrate using a suitable example. (2)
43. The pH of a salt solution depends on the hydrolysis of its ions.
    a) Out of the following, which can produce an acidic solution in water?
       (CH_3COONa, NH_4Cl, CH_3COONH_4, $NaCl$) (1)
    b) Explain the phenomenon of common ion effect with a suitable example. (2) [March 2012]
44. The principal goal of chemical synthesis is to maximize the conversion of reactants into products. Le-Chatlier's principle can be applied to achieve this goal.

    a) State Le-Chatlier's principle. (1)
    b) Predict the conditions to be applied to maximize the production of ammonia in the following reaction.
       $N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g)$; $\Delta H = -92.38$ kJ/mol (3)
    c) Comment on the effect of increasing pressure in the reaction, $2\ SO_3(g) \rightleftharpoons 2\ SO_2(g) + O_2(g)$ (1)
       [October 2011]
45. Common ion effect is a phenomenon based on Le-Chatlier's principle.
    a) Illustrate the common ion effect with an example. (2)
    b) If the concentration of hydrogen ion in a soft drink is 3×10^{-3} M, calculate its pH. (2)
    c) Identify the Lewis acids from the following: OH^-, BCl_3, NH_3, H^+ (1) [March 2011]
46. Lowry-Bronsted concept of acid and bases is based on the exchange of H^+ during a reaction.
    a) Illustrate with an example of the conjugate acid – base pair. (1½)
    b) Explain the Lewis concept of acids and bases. (1½)
    c) According to Lewis theory, classify the following into acids and bases:
       H_2O, NH_3, $AlCl_3$, OH^- (2) [September 2010]
47. When some sodium acetate is added to a solution of acetic acid, the concentration of unionized acetic acid increases.
    a) What is the phenomenon involved? Substantiate. (2)
    b) Consider the equilibrium, $AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$
       The solubility of AgCl is 1.06×10^{-5} mol/L at 298K. Find out its Ksp at this temperature. (2)
    c) What happens to the value of solubility and solubility product when HCl is passed through AgCl solution? (1)
       [March 2010]

48. The aqueous solutions of the ionic compounds NaCl, CH_3COONa and NH_4Cl show different pH.
    a) Identify the acidic, basic and neutral solutions among these. (2)
    b) Justify your answer. (3) [March 2009]
49. $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$
    a) Write down the expression for Kp. (1)
    b) What is the relation between Kp and Kc in the above reaction? (1) [June 2008]
50. $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$
    a) What happens to Kp of the above system if more chlorine is added to the system in equilibrium. (1)
    b) Give the relation between Kp and Kc in the above system. (1) [February 2008]

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