

SRIGAYATRI EDUCATIONAL INSTITUTIONS

INDIA

IONIC EQUILIBRIUM UT-03

- Which of the following order regarding basic strength of the given Bronsted bases in aqueous medium is correct
 - 1) $NO_2^- > CH_3COO^- > HCO_3^-$
 - 2) $NO_2^- > HCO_3^- > CH_3COO^-$
 - 3) $HCO_3^- > NO_2^- > CH_3COO^-$
 - 4) $HCO_3^- > CH_3COO^- > NO_2^-$
- The Conjugate base of hydrazoic acid is
 - 1) HN_3^-
 - 2) N_2^-
 - 3) N_3^-
 - 4) N^{3-}
- Which of the following sets contains Lewis acid only ?
 - 1) $BF_3, Ni^{2+}, SnCl_4$
 - 2) NH_3, C_5H_5N, H_2O
 - 3) BF_3, NH_3, H_2O
 - 4) $BF_3, SO_3, BeCl_2$
- The ionization constant of water at $25^\circ C$ is
 - 1) $1.8 \times 10^{-15} M$
 - 2) $1.8 \times 10^{-16} M$
 - 3) $1.0 \times 10^{-14} M$
 - 4) $1.0 \times 10^{-16} M$
- Which of the following solutions will have highest value of pH ?
 - 1) 0.1 M HCl
 - 2) 0.1 M H_2SO_4
 - 3) 0.1 M CH_3COOH
 - 4) 0.1 M in each of HCl and H_2SO_4
- Given 0.1 M oxalic acid ($K_{a_1} = 5.9 \times 10^{-2} M$ and $K_{a_2} = 6.4 \times 10^{-5} M$) Solution. The concentration of oxalate anion in the solution will be
 - 1) $5.9 \times 10^{-2} M$
 - 2) $0.87 \times 10^{-2} M$
 - 3) $6.4 \times 10^{-4} M$
 - 4) $6.4 \times 10^{-5} M$
- The ionization constant of acetic acid is $1.8 \times 10^{-5} M$ at $25^\circ C$ the value of K_b of acetate ions will be
 - 1) $5.56 \times 10^{-8} M$
 - 2) $5.56 \times 10^{-9} M$
 - 3) $5.56 \times 10^{-10} M$
 - 4) $1.8 \times 10^{-9} M$
- If $K_{a_1}(H_2CO_3) = 4.5 \times 10^{-7} M$ and $K_a(HCO_3^-) = 5.0 \times 10^{-11} M$, the pH of 0.1 M Na_2CO_3 Solution at $25^\circ C$ be
 - 1) 8.2
 - 2) 9.4
 - 3) 10.5
 - 4) 11.7
- The pH 0.1 M NaA is 3.0. The ionization constant of HA at 25° is
 - 1) $1.0 \times 10^{-7} M$
 - 2) $1.0 \times 10^{-8} M$
 - 3) $1.0 \times 10^{-9} M$
 - 4) $1.0 \times 10^{-10} M$
- The buffer capacity of a buffer having 0.1 M acetic acid and 0.05 M sodium acetate is
 - 1) 0.0333 M
 - 2) 0.0768 M
 - 3) 0.1152 M
 - 4) 0.2304 M
- The addition of small amount of acid or base to a buffer solution
 - 1) does not affect its pH value
 - 2) does not affect its buffer capacity
 - 3) does not affect its buffer range
 - 4) does affect the total amount of acid (or base) and its conjugate base (or acid) in the solution
- The solubility of $Ca_3(PO_4)_2$ in solution is $1.6 \times 10^{-7} mol L^{-1}$ Its solubility product is
 - 1) $2.56 \times 10^{-14} M^5$
 - 2) $4.22 \times 10^{-32} M^5$
 - 3) $1.13 \times 10^{-32} M^5$
 - 4) $2.26 \times 10^{-32} M^5$
- The minimum pH at which $Mg(OH)_2$ is precipitated from 0.1 M Mg (NO_3)₂ solution (given : $K_s(Mg(OH)_2) = (9 \times 10^{-15} M^3)$)
 - 1) 7.5
 - 2) 8.5
 - 3) 9.2
 - 4) 9.5
- The solubility of silver oxalate in 0.1 silver nitrate solution is $1.1 \times 10^{-9} M$ the solubility product of silver oxalate is
 - 1) $1.1 \times 10^{-9} M^3$
 - 2) $1.8 \times 10^{-9} M^3$
 - 3) $2.25 \times 10^{-10} M^3$
 - 4) $1.1 \times 10^{-11} M^3$

15. Which of the of the following statements in not correct?
- 1) The solubility of PbS in water as computed from solubility product is not affected if the hydrolysis of Pb^{2+} and S^{2-} are also considered
 - 2) The solubility of a sparingly soluble salt in water decreases if some common ion is present in water
 - 3) The solubility product of a salt is dependant on temperature
 - 4) The solubility of $Zn(OH)_2$ in water is dependant on the pH of the solution
16. The pH of a solution defined as
- 1) $pH = -\ln \left([H^+] / \text{mol dm}^{-3} \right)$
 - 2) $pH = -\log \left([H^+] / \text{mol dm}^{-3} \right)$
 - 3) $pH = -\log \left(\text{mol dm}^{-3} / [H^+] \right)$
 - 4) $pH = -\ln \left(\text{mol dm}^{-3} / [H^+] \right)$
17. Which of the following shows the highest percentage dissociation ?
- 1) 1.0M HCN ($K_{diss}^0 = 4.0 \times 10^{-10}$)
 - 2) 0.1 M HCN
 - 3) 1.0M HNO_2 ($K_{diss}^0 = 4.5 \times 10^{-4}$)
 - 4) 0.1 M HNO_2
18. A solution of NaCl is
- 1) acidic in nature
 - 2) alkaline in nature
 - 3) neutral in nature
 - 4) acidic at low temperature, neutral at room temperature and alkaline at high temperature
19. The pH 0.1 M Solution of the following salts increases in the order
- 1) $NaCl < NH_4Cl < NaCN < HCl$
 - 2) $HCl < NH_4Cl < NaCl < NaCN$
 - 3) $NaCN < NH_4Cl < NaCl < HCl$
 - 4) $HCl < NaCl < NaCN < NH_4Cl$
20. The solubility product of calcium phosphate is defined as
- 1) $K_{sp} = [Ca^{2+}][PO_4^{3-}]$
 - 2) $K_{sp} = \frac{[Ca^{2+}][PO_4^{3-}]}{[Ca_3(PO_4)_2]}$
 - 3) $K_{sp} = [Ca^{2+}]^3[PO_4^{3-}]^2$
 - 4) $K_{sp} = [Ca^{2+}]^2[PO_4^{3-}]^3$
28. For the reaction $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$, $\Delta H = -93.6 \text{ kJ mol}^{-1}$ which of the following is not true?
- 1) The pressure changes at constant temperature do not affect the equilibrium constant
 - 2) The volume changes at constant temperature do not affect the equilibrium constant
 - 3) The formation of NH_3 is decreased at higher temperature
 - 4) The formation of NH_3 is increased at higher temperature
21. In the reaction $HCN + H_2O \rightleftharpoons H_3O^+ + CN^-$, the conjugate acid – base pair is
- 1) HCN, H_2O
 - 2) H_3O^+, CN^-
 - 3) HCN, H_3O^+
 - 4) HCN, CN^-
22. The strongest base amongst OH^-, F^-, NH_2^- and CH_3^- is
- 1) NH_2^-
 - 2) CH_3^-
 - 3) F^-
 - 4) OH^-
23. The first and second standard dissociation of an acid H_2A are 1.0×10^{-5} and 5.0×10^{-10} respectively, overall standard dissociation constant of acid will be
- 1) 5.0×10^{-5}
 - 2) 5.0×10^{15}
 - 3) 5.0×10^{-15}
 - 4) 0.2×10^{15}
24. In aqueous solution the ionization constants for carbonic acid are $K_1^0 = 4.2 \times 10^{-7}$ and $K_2^0 = 4.8 \times 10^{-11}$ select correct statement for a saturated 0.34 M solution of the carbonic acid
- 1) The Concentration of H^+ is double that of CO_3^{2-}
 - 2) The Concentration of CO_3^{2-} is 0.034 M
 - 3) The Concentration of CO_3^{2-} is greater than that of HCO_3^-

- 4) the concentrations of H^+ and HCO_3^- are approximately equal
25. The pH of a 0.1 molar solution of the acid HQ is 3. The value of the ionization constant k_a of this acid is
 1) $3 \times 10^{-1} M$ 2) $1 \times 10^{-3} M$ 3) $1 \times 10^{-5} M$ 4) $1 \times 10^{-7} M$
26. Among the following oxoacids, the correct order of acid strength is
 1) $HClO_2 > HClO_4 > HClO_3 > HOCl$ 2) $HOCl > HClO_2 > HClO_3 > HClO_4$
 3) $HClO_4 > HOCl > HClO_2 > HClO_3$ 4) $HClO_4 > HClO_3 > HClO_2 > HOCl$
27. Zirconium phosphate $[Zr_3(PO_4)_4]$ dissociates into three zirconium cations of charge +4 and four phosphate anions of charge -3. If molar solubility of zirconium phosphate is denoted by s and the solubility product by K_{sp} which of the following relationship between s and K_{sp} is Correct ?
 1) $s = k_{sp} / (6912)^{1/7}$ 2) $s = (k_{sp} / 144)^{1/7}$ 3) $s = (k_{sp} / 6912)^{1/7}$ 4) $s = (k_{sp} / 6912)^7$

INTEGER TYPE QUESTIONS

28. How much water must be added to 300 mL of 0.2 M solution of $CH_3COOH(K_a = 1.8 \times 10^{-5})$ for the degree of dissociation of the acid to double?
- 29) K_{sp} of $Mg(OH)_2$ is 4×10^{-12} the no. of moles of Mg^{2+} ions in one litre of its saturated solution in 0.1 M NaOH is?
- 30) The pH of a saturated aqueous solution of CO_2 is 5 ; For H_2CO_3 , $K_{a1} = 10^{-7}$ and $K_{a2} = 10^{-11}$. At the given pressure the solubility of CO_2 in water is $10^{-2} (M)$. What is the value of $-\log [CO_3^{2-}]$ in the nearest possible integers?

KEY

1	4	2	3	3	1	4	2	5	3	6	4	7	3	8	4	9	3	10	2
11	3	12	3	13	1	14	2	15	1	16	2	17	4	18	3	19	2	20	3
21	4	22	2	23	3	24	4	25	3	26	4	27	3	28	900	29	2	30	7

HINTS & SOLUTIONS

1. The order of the conjugate acids is $HNO_2 > CH_3COOH > H_2CO_3$. The base strength follows the reverse order i.e $HCO_3^- > CH_3COO^- > NO_2^-$

2. The hydrazoic acid is N_3H its conjugate base is N_3^-

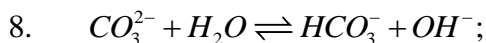
3. This species BF_3 , Ni^{2+} & $SnCl_4$, can accept lone pair of electrons

$$4. K_c = \frac{[H_3O^+][OH]}{[H_2O]^2} = \frac{(10^{-7} M)^2}{55.56 M} = 1.80 \times 10^{-16} M$$

5. 0.1 M CH_3COOH will have minimum $[H_3O^+]$ and hence its pH will be maximum

6. In diprotic acid H_2A , $[A^{2-}] = K_{a2}$

$$7. K_b = K_w / K_a = 1.0 \times 10^{-14} M^2 / 1.8 \times 10^{-5} M = 5.56 \times 10^{-10} M$$



$$pH = \frac{1}{2} [pK_w^0 + pK_a^0(HCO_3^-) + \log(c/(M))] = \frac{1}{2} [14 - \log(5 \times 10^{-11}) + \log(0.1)] = \frac{1}{2} [14 + 10.30 - 1] = 11.65$$

$$9. pH = 3.0 \text{ implies } [H^+] = 10^{-3} M \text{ also } [H^+] = \sqrt{\{K_b(A^-)\}c} \text{ or } K_b(A^-) = [H^+]^{2/c}$$

$$\text{That is } K_b(A^-) = (10^{-3} M)^2 / (0.1 M) = 10^{-5} M$$

$$\text{Finally } K_a(HA) = K_w / K_b(A^-) = (10^{-14} M^2) / (10^{-5} M) = 10^{-9} M$$

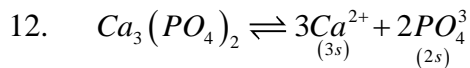
10. By definition, buffer capacity of an acidic buffer is

$$\frac{\partial b}{\partial(pH)} = 2.303 \left[\frac{b(a-b)}{a} \right]$$

Where $a = [\text{acid}] + [\text{salt}]$ and $b = [\text{salt}]$. Hence

$$\frac{\partial b}{\partial(pH)} = 2.303 \left[\frac{(0.05 M)(15 M - 0.05 M)}{(0.15 M)} \right] = 0.0768 M$$

11. The addition of small amount of acid or base does not change the total amount of acid (or base) and conjugate. The pH value and buffer capacity change after the addition of acid or base.



$$K_s = [Ca^{2+}]^3 [PO_4^{3-}]^2 = (3s)^3 (2s)^2 = 108s^5 = (108)(1.6 \times 10^{-7} M)^5 = 1.13 \times 10^{-32} M^5$$

$$13. \quad K_s(Mg(OH)_2) = [Mg^{2+}][OH^-]^2 \text{ Hence } [OH^-] = \left(\frac{K_s}{[Mg^{2+}]} \right) = \left(\frac{9 \times 10^{-15}}{0.1M} \right) = 3.0 \times 10^{-7} M$$

$$pOH = -\log(3.0 \times 10^{-7}) = 6.52 \quad pH = 14 - 6.52 = 7.48$$

$$14. \quad K_s = [Ag^+]^2 [Ox^{2-}] = (0.1M)^2 (1.1 \times 10^{-9} M) = 1.1 \times 10^{-11} M^3$$

15. The solubility of PbS is increased if the hydrolysis of Pb^{2+} and S^{2-} ions are also considered. The solubility of $Zn(OH)_2$ is pH dependent due to the reaction between OH^- from $Zn(OH)_2$ and H^+ ions (i.e. pH) present in the solution

16. Conceptual

17. Ostwald dilution law; more dilute the solution, more the dissociation

18. Solution is neutral because no hydrolysis of Na^+ and Cl^- take place.

19. HCl is the strongest acid. Its pH will be minimum NaCl does not hydrolyze in solution its pH = 7

NH_4^+ in NH_4Cl on hydrolysis produces H^+ Hence, its pH will be slightly less than 7

CN^- in NaCN on hydrolysis produces OH^- . Hence, its pH will be slightly greater than 7

20. Conceptual

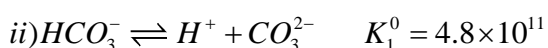
21. Conceptual

22. The weakest acid amongst H_2O, HF, NH_3 and CH_4 is CH_4 the strongest base will be CH_3^-

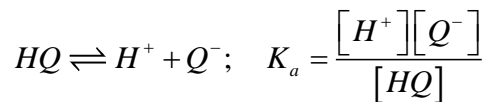
23. The overall standard dissociation constant of the acid is

$$K_a^0 = K_{a1}^0 K_{a2}^0 = (1.0 \times 10^{-5})(5.0 \times 10^{-10}) = 5.0 \times 10^{-15}$$

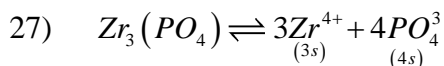
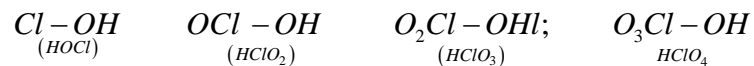
24. Carbonic acid ionizes as



25. For a weak acid, we have



26. The larger the number of oxygen atoms attached to chlorine, greater the electron pull towards oxygen, hence, more easy to remove hydrogen from the acid. The given acids are



$$K_{sp} = [Zr^{4+}]^3 [PO_4^{3-}]^4 = (3s)^3 (4s)^4 = 6912 s^7$$

$$\text{Hence } s = (K_{sp} / 6912)^{1/7}$$

28) As we know $C\alpha^2 = K_a; \alpha = \sqrt{K_a / C}$

$$\text{According to the given condition, } \alpha_2 / \alpha_1 = 2 = \sqrt{C_1 / C_2}; C_2 = 0.2 / 4$$

$$\text{Again, } M_1V_1 = M_2V_2$$

$$V_2 = 300 \times 0.2 \times 4 / 0.2 = 1200 \text{ ml}$$

So, 900(=1200-300) mL of water should be added

29) $K_{sp} = [Mg^{2+}][OH^-]^2$

Let the concentration of Mg^{2+} ions to form saturated solution be s mol/litre

$$4 \times 10^{-12} = 5 \times (0.1)^2$$

$$s = 4 \times 10^{-10} \text{ mol / litre}$$

Volume of solution = 1 litre

$$\text{Number of moles of } Mg^{2+} = \text{Molarity} \times \text{Volume} = 4 \times 10^{-10} \times 1 = 4 \times 10^{-10} \text{ mol}$$

30) $HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$

$$\frac{[CO_3^{2-}][H^+]}{[HCO_3^-]} = 10^{-11}$$

$$10^{-11} \times 10^{-4}$$

$$x^2 = 10^{-15}$$

$$x = 10^{-7} = CO_3^{-2}$$

$$\log[10^{-7}] = 7$$