SRIGAYATRI EDUCATIONAL INSTITUTIONS

INDIA

IONIC EQUILIBRIUM UT-03

1. 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) $HCO_3^- > CH_3COO^- > NO_2^-$

2. The Conjugate base of hydrzoic acid is

1) HN_3^- 2) N_2^- 3) N_3^- 4) N^{3-}

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) $BF_3, SO_3, BeCl_2$

4. The ionization constant of water at 25^0C is

1) $1.8\times10^{-15}M$ 2) $1.8\times10^{-16}M$ 3) $1.0\times10^{-14}M$ 4) $1.0\times10^{-16}M$

5. 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

6. Given 0.1 M oxalic acid $\left(K_{a_1} = 5.9\times10^{-2}M \ \ and\ K_{a_2} = 6.4\times10^{-5}M\right)$ Solution. The concentration of oxalate anion in the solution will be

1) $5.9\times10^{-2}M$ 2) $0.87\times10^{-2}M$ 3) $6.4\times10^{-4}M$ 4) $6.4\times10^{-5}M$

7. The ionization constant of acctic acid is 1.8×10^5 M at 25^0C the value of K_b of acetate ions will be

1) $5.56\times10^{-8}M$ 2) $5.56\times10^{-9}M$ 3) $5.56\times10^{-10}M$ 4) $1.8\times10^{-9}M$

8. If $K_{a1}\left(H_2CO_3\right) = 4.5\times10^{-7}$ M and $K_a\left(HCO_3^-\right) = 5.0\times10^{-11}M$, the pH of 0.1 M Na_2CO_3 Solution at 25^0C be

1) 8.2 2) 9.4 3) 10.5 4) 11.7

9. The pH 0.1 M NaA is 3.0. The ionization constant of HA at 25^0 is

1) $1.0\times10^{-7}M$ 2) $1.0\times10^{-8}M$ 3) $1.0\times10^{-9}M$ 4) $1.0\times10^{-10}M$

10. 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

11. 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

12. The solubility of $Ca_3\left(PO_4\right)_2$ in solution is $1.6\times10^{-7}mol\,L^{-1}$ Its solubility product is

1) $2.56\times10^{-14}M^5$ 2) $4.22\times10^{-32}M^5$ 3) $1.13\times10^{-32}M^5$ 4) $2.26\times10^{-32}M^5$

13. The minimum pH at which $Mg\left(OH\right)_2$ is precipitated from 0.1 M Mg $\left(NO_3\right)_2$ solution (given : $K_5\left(Mg\left(OH\right)_2\right) = \left(9\times10^{-15}M^3\right)$

1) 7.5 2) 8.5 3) 9.2 4) 9.5

14. The solubility of silver oxalate in 0.1 silver nitrate solution is $1.1\times10^{-9}M$ the solubility product of silver oxalate is

1) $1.1\times10^{-9}M^3$ 2) $1.8\times10^{-9}M^3$ 3) $2.25\times10^{-10}M^3$ 4) $1.1\times10^{-11}M^3$

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 = - In $\left(\left[H^+\right]/moldm^{-3}\right)$ 2) pH = - log $\left(\left[H^+\right]/mol\,dm^{-3}\right)$

3) pH = - log $\left(mol\,dm^{-3}/\left[H^+\right]\right)$ 4) pH = - In $\left(mol\,dm^{-3}/\left[H^+\right]\right)$

17. Which of the following shows the highest percentage dissociation ?

1) $1.0M\ HCN\left(K^0_{diss}=4.0\times10^{-10}\right)$ 2) 0.1 M HCN

3) $1.0M\ HNO_2\left(K^0_{diss}=4.5\times10^{-4}\right)$ 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) $K_{sp}=\left[Ca^{2+}\right]\left[PO_4^{3-}\right]$ 2) $K_{sp}=\dfrac{\left[Ca^{2+}\right]\left[PO_4^{3-}\right]}{\left[Ca_3\left(PO_4\right)_2\right]}$

3) $K_{sp}=\left[Ca^{2+}\right]^3\left[PO_4^{3-}\right]^2$ 4) $K_{sp}=\left[Ca^{2+}\right]^2\left[PO_4^{3-}\right]^3$

28. For the reaction $N_{2(g)}+3H_{2(g)}\rightleftharpoons 2NH_{3(g)},\Delta H=-93.6kJmol^{-1}$ 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 $HCN+H_20\rightleftharpoons H_3O^++CN^-$, **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 $K_1^0=4.2\times10^{-7}$ **and** $K_2^0=4.8\times10^{-11}$ **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) $3\times10^{-1}M$ 2) $1\times10^{-3}M$ 3) $1\times10^{-5}M$ 4) $1\times10^{-7}M$

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) $HClO_4 > HClO_3 > HClO_2 > HClO$

27. **Zirconium phosphate $\left[Zr_3\left(PO_4\right)_4\right]$ 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 is Correct ?**

1) $s = k_{sp}/\left(6912\right)^{1/7}$ 2) $s = \left(k_{sp}/144\right)^{1/7}$ 3) $s = \left(k_{sp}/6912\right)^{1/7}$ 4) $s = \left(k_{sp}/6912\right)^{7}$

INTEGER TYPE QUESTIONS

28. **How much water must be added to 300 mL of 0.2 M solution of $CH_3COOH(K)_a=1.8\times10^{-5}$ 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, $Ka_1=10^{-7}$ and $Ka_2=10^{-11}$. 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 hydrzoic 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. $K_c = \frac{[H_3O^+][OH]}{[H_2O]^2} = \frac{(10^{-7}M)^2}{55.56M} = 1.80\times10^{16}M$

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. $K_b = K_w / K_a = 1.0\times10^{-14}M^2 / 1.8\times10^{-5}M = 5.56\times10^{-10}M$

8. $CO_3^{2-} + H_2O \rightleftharpoons HCO_3^- + OH^-;$

$$pH = \frac{1}{2}\left[pK_w^0 + pK_a^0\left(HCO_3^-\right) + \log\left(c/(M)\right)\right] = \frac{1}{2}\left[14 - \log\left(5\times10^{-11}\right) + \log(0.1)\right] = \frac{1}{2}[14 + 10.30 - 1] = 11.65$$

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

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

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 = [acid] + [salt] and b = [salt]. Hence

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

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.

12. $Ca_3\left(PO_4\right)_2 \rightleftharpoons \underset{(3s)}{3Ca^{2+}} + \underset{(2s)}{2PO_4^{3}}$

$K_s = \left[Ca^{2+}\right]^3\left[PO_4^{3-}\right] = (3s)^3(2s)^2 = 108s^5 = (108)\left(1.6\times10^{-7}M\right)^5 = 1.13\times10^{-32}M^5$

13. $K_s\left(Mg\left(OH_2\right)\right) = \left[Mg^{2+}\right]\left[OH^-\right]^2$ *Hence* $\left[OH^-\right] = \left(\frac{K_s}{\left[Mg^{2+}\right]}\right) = \left(\frac{9\times10^{-15}}{0.1M}\right) = 3.0\times10^{-7}M$

$pOH = -\log\left(3.0\times10^{-7}\right) = 6.52$ pH = 14 – 6.52 = 7.48

14. $K_s = \left[Ag^+\right]^2\left[Ox^{2-}\right] = (0.1M)^2\left(1.1\times10^{-9}M\right) = 1.1\times10^{-11}M^3$

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

$K_a^0 = K_{a1}^0 K_{a2}^0 = \left(1.0\times10^{-5}\right)\left(5.0\times10^{-10}\right) = 5.0\times10^{-15}$

24. Carbonic acid ionizes as

$i) H_2CO_3 \rightleftharpoons H^+ + HCO_3^- \qquad K_1^0 = 4.2\times10^{7}$

$ii) HCO_3^- \rightleftharpoons H^+ + CO_3^{2-} \qquad K_1^0 = 4.8\times10^{11}$

25. For a weak acid, we have

$$HQ \rightleftharpoons H^+ + Q^-; \quad K_a = \frac{\left[H^+\right]\left[Q^-\right]}{\left[HQ\right]}$$

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

$$\underset{(HOCl)}{Cl-OH} \qquad \underset{(HClO_2)}{OCl-OH} \qquad \underset{(HClO_3)}{O_2Cl-OHl;} \qquad \underset{HClO_4}{O_3Cl-OH}$$

27) $Zr_3\left(PO_4\right) \rightleftharpoons \underset{(3s)}{3Zr^{4+}} + \underset{(4s)}{4PO_4^3}$

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

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

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

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

Again, $M_1V_1 = M_2V_2$

V_2=300 ×0.2×4 / 0.2=1200 ml

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

29) Ksp=[Mg^{2+}][OH^-]2

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

4×10^{-12}=5×(0.1)2

s=4 ×10^{-10}mol / litre

Volume of solution =1 litre

Number of moles of Mg^{2+}= Molarity x Volume=4 ×10^{-10} ×1= 4 ×10^{-10}mol

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

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

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

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

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

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