IONIC EQUILIBRIUM

1. The solubility product of PbI_2 is 8.0×10^{-9}. The solubility of lead iodide in 0.1 molar solution of lead nitrate is $x \times 10^{-6}$ mol/L. The value of x is ________. (Rounded off to the nearest integer)

$[\text{Given} : \sqrt{2} = 1.41]$

2. The solubility of AgCN in a buffer solution of pH = 3 is x. The value of x is:

[Assume : No cyano complex is formed; $K_{sp}(AgCN) = 2.2 \times 10^{-16}$ and $K_a(HCN) = 6.2 \times 10^{-10}$]

(1) 0.625×10^{-6} (2) 1.9×10^{-5}

(3) 2.2×10^{-16} (4) 1.6×10^{-6}

3. 0.4 g mixture of NaOH, Na_2CO_3 and some inert impurities was first titrated with $\frac{N}{10}$ HCl using phenolphthalein as an indicator, 17.5 mL of HCl was required at the end point. After this methyl orange was added and titrated. 1.5 mL of same HCl was required for the next end point. The weight percentage of Na_2CO_3 in the mixture is _______. (Rounded-off to the nearest integer)

4. The solubility of $Ca(OH)_2$ in water is :

[Given : The solubility product of $Ca(OH)_2$ in water = 5.5×10^{-6}]

(1) 1.77×10^{-6} (2) 1.11×10^{-6}

(3) 1.11×10^{-2} (4) 1.77×10^{-2}

5. Consider titration of NaOH solution versus 1.25M oxalic acid solution. At the end point following burette readings were obtained.

(i) 4.5 mL (ii) 4.5 mL

(iii) 4.4 mL (iv) 4.4 mL

(v) 4.4 mL

If the volume of oxalic acid taken was 10.0 mL then the molarity of the NaOH solution is _______M. (Rounded-off to the nearest integer)

6. The pH of ammonium phosphate solution, if pK_a of phosphoric acid and pk_b of ammonium hydroxide are 5.23 and 4.75 respectively, is ______.

7. Two salts A_2X and MX have the same value of solubility product of 4.0×10^{-12}. The ratio of their molar solubilities i.e. $\frac{S(A_2X)}{S(MX)}$ = _______.

(Round off to the Nearest Integer).

8. Sulphurous acid (H_2SO_3) has $Ka_1 = 1.7 \times 10^{-2}$ and $Ka_2 = 6.4 \times 10^{-8}$. The pH of 0.588 M H_2SO_3 is ________. (Round off to the Nearest Integer)

9. 0.01 moles of a weak acid HA($K_a = 2.0 \times 10^{-6}$) is dissolved in 1.0 L of 0.1 M HCl solution. The degree of dissociation of HA is ________ $\times 10^{-5}$ (Round off to the Nearest Integer).

[Neglect volume change on adding HA. Assume degree of dissociation <<1]

10. In order to prepare a buffer solution of pH 5.74, sodium acetate is added to acetic acid. If the concentration of acetic acid in the buffer is 1.0 M, the concentration of sodium acetate in the buffer is _____ M. (Round off to the Nearest Integer).

[Given : pKa (acetic acid) = 4.74]

11. The solubility of $CdSO_4$ in water is 8.0×10^{-4} mol L^{-1}. Its solubility in 0.01 M H_2SO_4 solution is ______$\times 10^{-6}$ mol L^{-1}. (Round off to the Nearest integer) (Assume that solubility is much less than 0.01 M)

12. 10.0 ml of Na_2CO_3 solution is titrated against 0.2 M HCl solution. The following titre values were obtained in 5 readings.
4.8 ml, 4.9 ml, 5.0 ml, 5.0 ml and 5.0 ml
Based on these readings, and convention of titrimetric estimation of concentration of Na_2CO_3 solution is ________mM.
(Round off to the Nearest integer)

13. A solution is 0.1 M in Cl^- and 0.001 M in CrO_4^{2-}. Solid $AgNO_3$ is gradually added to it Assuming that the addition does not change in volume and $K_{sp}(AgCl) = 1.7 \times 10^{-10}$ M^2 and $K_{sp}(Ag_2CrO_4) = 1.9 \times 10^{-12}$ M^3.
Select **correct** statement from the following :
(1) AgCl precipitates first because its K_{sp} is high.
(2) Ag_2CrO_4 precipitates first as its K_{sp} is low.
(3) Ag_2CrO_4 precipitates first because the amount of Ag^+ needed is low.
(4) AgCl will precipitate first as the amount of Ag^+ needed to precipitate is low.

14. The water having more dissolved O_2 is :
(1) boiling water (2) water at 80°C
(3) polluted water (4) water at 4°C

15. Assuming that $Ba(OH)_2$ is completely ionised in aqueous solution under the given conditions the concentration of H_3O^+ ions in 0.005 M aqueous solution of $Ba(OH)_2$ at 298 K is ________ $\times 10^{-12}$ mol L^{-1}.
(Nearest integer)

16. Given below are two statements.
Statement I: In the titration between strong acid and weak base methyl orange is suitable as an indicator.
Statement II: For titration of acetic acid with NaOH phenolphthalein is not a suitable indicator.
In the light of the above statements, choose the **most appropriate** answer from the options given below:
(1) **Statement I** is false but **Statement II** is true
(2) **Statement I** is true but **Statement II** is false
(3) Both **Statement I** and **Statement II** are true
(4) Both **Statement I** and **Statement II** are false

17. The OH^- concentration in a mixture of 5.0 mL of 0.0504 M NH_4Cl and 2 mL of 0.0210 M NH_3 solution is $x \times 10^{-6}$ M. The value of x is _______. (Nearest integer)
[Given $K_w = 1 \times 10^{-14}$ and $K_b = 1.8 \times 10^{-5}$]

18. The overall stability constant of the complex ion $[Cu(NH_3)_4]^{2+}$ is 2.1×10^{13}. The overall dissociations constant is $y \times 10^{-14}$. Then y is ____.(Nearest integer)

19. The number of moles of NH_3, that must be added to 2 L of 0.80 M $AgNO_3$ in order to reduce the concentration of Ag^+ ions to 5.0×10^{-8} M ($K_{formation}$ for $[Ag(NH_3)_2]^+ = 1.0 \times 10^8$) is _______. (Nearest integer)
[Assume no volume change on adding NH_3]

20. A_3B_2 is a sparingly soluble salt of molar mass M (g mol^{-1}) and solubility x g L^{-1}. The solubility product satisfies $K_{sp} = a\left(\frac{x}{M}\right)^5$. The value of a is ________. (Integer answer)

21. The pH of a solution obtained by mixing 50 mL of 1 M HCl and 30 mL of 1 M NaOH is $x \times 10^{-4}$. The value of x is __________. (Nearest integer) [log 2.5 = 0.3979]

22. The molar solubility of $Zn(OH)_2$ in 0.1 M NaOH solution is $x \times 10^{-18}$ M. The value of x is _____(Nearest integer)
(Given : The solubility product of $Zn(OH)_2$ is 2×10^{-20})

SOLUTION

1. Official Ans. by NTA (141)

Sol. Given : $[K_{sp}]_{PbI_2} = 8\times10^{-9}$

To calculate : solubility of PbI_2 in 0.1 M sol of $Pb(NO_3)_2$

(I) $Pb(NO_3)_2 \rightarrow Pb^{+2}_{(aq)} + 2NO_3^-(aq)$

0.1 M – –

– 0.1M 0.2M

(II) $PbI_2(s) = Pb^{+2}(aq) + 2I^-(aq)$

s 2s

= s + 0.1

= 0.1

Now : $K_{sp} = 8\times10^{-9} = [Pb^{+2}][I^-]^2$

$\Rightarrow 8\times10^{-9} = 0.1\times(2s)^2$

$\Rightarrow 8\times10^{-8} = 4s^2 \Rightarrow s = \sqrt{2}\times10^{-4}$

$\Rightarrow \boxed{S = 141\times10^{-6}M}$

$\Rightarrow x = 141$

2. Official Ans. by NTA (2)

Sol. $\frac{K_{sp}}{Ka} = \frac{s^2}{(H^+)}$; $s = \sqrt{\frac{K_{sp}}{K_a}(H^+)}$

$$s = \sqrt{\frac{2.2\times10^{-16}}{6.2\times10^{-10}}\times10^{-3}}$$

$s = 1.9\times10^{-5}$

Hence answer is (2)

3. Official Ans. by NTA (4)

Sol. Upto first end point

gm equi. of $(NaOH + Na_2CO_3) = HCl$

$x + y\times1 = \frac{1}{10}\times17.5$

$x + y = 1.75$ ...(1)

Upto second end point

$NaOH + Na_2CO_3 \equiv HCl$

$x + y\times2 = \frac{1}{10}\times19$

$x + 2y = 1.9$ ...(2)

$y = 0.15$

$\%Na_2CO_3 = \frac{0.15\times10^{-3}\times106}{0.4}\times100$

$= 3.975\%$

$= 4\%$

Hence answer is (4)

4. Official Ans. by NTA (3)

Sol. $Ca(OH)_2 \rightleftharpoons Ca^{2+}(aq) + 2OH^-(aq)$

s 2s

$k_{sp} = s(2s)^2 \Rightarrow 5.5\times10^{-6} = 4S^3$

$\Rightarrow s = \left(\frac{5.5}{4}\right)^{\frac{1}{3}}\times10^{-2} = 1.11\times10^{-2}$

5. Official Ans. by NTA (6)

Sol. $V_{NaOH} = 4.4$ ml

eq. of NaOH = eq. of $H_2C_2O_4$

or, $M\times4.4\times1 = 1.25\times10\times2$

or, M = 5.68 M

∴ Nearest integer answer is 6

6. Official Ans by NTA (7)

Sol. Since $(NH_4)_3PO_4$ is salt of weak acid (H_3PO_4) & weak base (NH_4OH).

$pH = 7 + \frac{1}{2}(pka - pkb)$

$= 7 + \frac{1}{2}(5.23 - 4.75)$

$= 7.24 \approx 7.$

7. Official Ans. by NTA (50)

Sol. For A_2X

$A_2X \rightarrow 2A^+ + X^{2-}$

$2S_1 \quad S_1$

$K_{sp} = 4S_1^3 = 4\times10^{-12}$

$S_1 = 10^{-4}$

for MX

$MX \rightarrow M^+ + X^-$

$S_2 \quad S_2$

$K_{sp} = S_2^2 = 4\times10^{-12}$

$S_2 = 2 \times 10^{-6}$

so $\frac{S_{A_2X}}{S_{MX}} = \frac{10^{-4}}{2\times10^{-6}} = 50$

8. Official Ans. by NTA (1)

Sol. H_2SO_3 [Dibasic acid]

c = 0.588 M

⇒ pH of solution ⇒ due to First dissociation only since $K_{a_1} >> Ka_2$

⇒ First dissociation of H_2SO_3

$H_2SO_3(aq) \rightleftharpoons H^{\oplus}(aq) + HSO_3^-(aq) : ka_1 = 1.7\times10^{-2}$

t = 0 C

t C–x x x

⇒ $Ka_1 = \frac{1.7}{100} = \frac{[H^{\oplus}][HSO_3^-]}{[H_2SO_3]}$

⇒ $\frac{1.7}{100} = \frac{x^2}{(0.58 - x)}$

⇒ $1.7 \times 0.588 - 1.7x = 100\,x^2$

⇒ $100x^2 + 1.7x - 1 = 0$

⇒ $[H^{\oplus}] = x = \frac{-1.7 + \sqrt{(1.7)^2 + 4\times100\times1}}{2\times100} = 0.09186$

Therefore pH of sol. is : pH = – log $[H^{\oplus}]$

⇒ pH = –log (0.09186) = 1.036 $\simeq$ 1

9. Official Ans. by NTA (2)

Sol. $HA \rightleftharpoons H^+ + A^-$

Initial conc. 0.01M 0.1M 0

Equ. conc. (0.01 – x) (0.1 + x) xM

$\approx$ 0.01M $\approx$ 0.1M

Now, $K_a = \frac{[x^+][A^-]}{[HA]} \Rightarrow 2\times10^{-6} = \frac{0.1\times x}{0.01}$

$\therefore$ $x = 2 \times 10^{-7}$

Now, $\alpha = \frac{x}{0.01} = \frac{2\times10^{-7}}{0.01} = 2\times10^{-5}$

10. Official Ans. by NTA (10)

Sol. $pH = pKa + \log\frac{[CB]}{[WA]}$

$5.74 = 4.74 + \log\frac{[CB]}{1}$

⇒ [CB] = 10 M

11. Official Ans. by NTA (64)

Sol. In pure water,

$K_{sp} = S^2 = (8 \times 10^{-4})^2$

$= 64 \times 10^{-8}$

In 0.01 M H_2SO_4

$H_2SO_{4(aq)} \rightarrow 2H^+_{(aq)} + SO_4^{2-}(aq.)$

0.02 0.01

$BaSO_{4(s)} \rightleftharpoons Ba^{2+}_{(aq.)} + SO_{4\,(aq)}^{2-}$

x x (x + 0.01)

$K_{sp} = x\,(x + 0.01)$

$= 64 \times 10^{-8}$

$x + 0.01 \cong 0.01$ M

So, $x\,(0.01) = 64 \times 10^{-8}$

$x = 64 \times 10^{-6}$ M

12. Official Ans. by NTA (50)

Sol. Most precise volume of HCl = 5 ml

at equivalence point

Meq. of Na_2CO_3 = meq. of HCl.

Let molarity of $Na2CO_3$

solution = M, then

$M \times 10 \times 2 = 0.2 \times 5 \times 1$

M = 0.05 mol / L

$= 0.05 \times 1000$

= 50 mM

13. Official Ans. by NTA (4)

Sol. **(i)** $[Ag^+]$ required to ppt AgCl(s)

$Ksp = IP = [Ag^+][Cl^-] = 1.7 \times 10^{-10}$

$[Ag^+] = 1.7 \times 10^{-9}$

(ii) $[Ag^+]$ required to ppt $Ag_2CrO_4(s)$

$Ksp = IP = [Ag+]^2 [CrO_4^{-2}] = 1.9 \times 10^{-12}$

$[Ag^+] = 4.3 \times 10^{-5}$

$[Ag^+]$ required to ppt AgCl is low so AgCl will ppt 1st.

14. Official Ans. by NTA (4)

Sol. On heating concentration of O_2 in water decreases. So boiling water and water at 80°C having less O_2 concentration. Polluted water also having less O_2 concentration. So water at 4°C having maximum O_2 concentration.

15. Official Ans. by NTA (1)

Sol. $Ba(OH)_2 \rightarrow Ba^{+2} + 2OH^-$

$\downarrow$

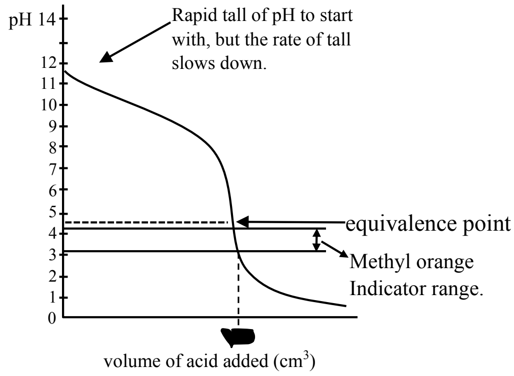
$2 \times 0.005 = 0.01 = 10^{-2}$

At 298 K : in aq. solution $[H_3O^+][OH^-] = 10^{-14}$

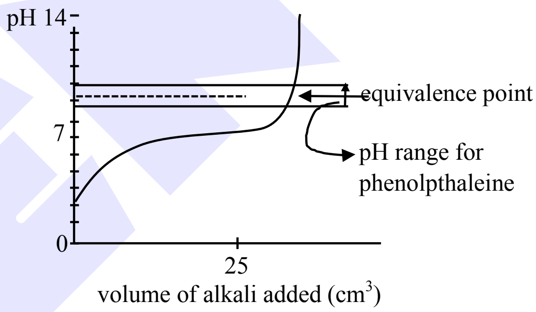
$$[H_3O^+] = \frac{10^{-14}}{10^{-2}} = 10^{-12}$$

16. Official Ans. by NTA (2)

Sol. Titration curve for strong acid and weak base initially a buffer of weak base and conjugate acid is :



Formed, thus pH falls slowly and after equivalence point, so the pH falls sharply so methyl arrange, having pH range of 3.2 to 4.4 will weak as indicator. So statement-I is correct.



Titration curve for weak acid and strong base (NaOH)

Initially weak acid will form a buffer so pH increases slowly but after equivalence point. it rises sharply covering range of phenolphthalein so it will be suitable indicator so statement-II is false.

17. Official Ans. by NTA (3)

Sol. $\left[NH_4^+\right] = 0.0504$ & $\left[NH_3\right] = 0.0210$

$$\text{So } K_b = \frac{[NH_4^+][HO^-]}{[NH_3]}$$

$$[HO^-] = \frac{K_b \times [NH_3]}{[NH_4^+]} = 1.8 \times 10^{-5} \times \frac{2}{5} \times \frac{210}{504}$$

$= 3 \times 10^{-6}$

18. Official Ans. by NTA (5)

Sol. Given $k_f = 2.1 \times 10^{13}$

$$K_d = \frac{1}{k_f} = 4.7 \times 10^{-14}$$

$\therefore$ y = 4.7 ≈ 5

19. Official Ans. by NTA (4)

Sol. Let moles added = a

$$Ag^{+}_{(aq.)} + 2NH_{3(aq.)} \rightleftharpoons Ag(NH_3)^{+}_{2(aq.)}$$

t = 0   0.8 $\left(\frac{a}{2}\right)$

t = ∞ 5×10^{-8} $\left(\frac{a}{2} - 1.6\right)$ 0.8

$$\frac{0.8}{(5\times10^{-8})\left(\frac{a}{2}-1.6\right)^2} = 10^8$$

$$\Rightarrow \frac{a}{2} - 1.6 = 0.4 \Rightarrow a = 4$$

20. Official Ans. by NTA (108)

Sol. $A_3B_2\,(s) \rightleftharpoons 3A^{+2}_{(aq)} + 2B^{-3}_{(aq)}$

3s   2s

$K_{SP} = (3s)^3\,(2s)^2$

$K_{SP} = 108\,S^5$ & s = (X/M)

$$K_{SP} = 108\left(\frac{x}{m}\right)^5$$

given $K_{SP} = a\left(\frac{x}{m}\right)^5$

comparing a = 108

21. Official Ans. by NTA (6021)

Sol. HCl (aq.) + NaOH (aq.) $\rightarrow$ NaCl(aq.) + $H_2O(\ell)$

50 ml,1M   30ml, 1M   –   –

t = 0   50 mm   30 mm

t = ∞   20 mm   –

$$[HCl] = \frac{20}{80} = \frac{1}{4}M = 2.5 \times 10^{-1}M$$

pH = –log 2.15×10^{-1} = 1 – 0.3979 = 0.6021

pH = 6021×10^{-4}

22. Official Ans. by NTA (2)

Sol. $Zn(OH)_2\,(s) \rightleftharpoons Zn^{+2}\,(aq) + 2OH^{-}\,(aq)$

S   (0.1 + 2s) ≃ 0.1

$K_{sp} = S(0.1)^2$

$2 \times 10^{-20} = s \times 10^{-2} \Rightarrow s = 2 \times 10^{-18}$

$= x \times 10^{-18}$

x = 2