Daily Tutorial Sheet-1	JEE Advanced (Archive)

1.(A) The order of acidic strength of conjugate acids is $HOCl < HClO_2 < HClO_3 < HClO_4$

Reverse is the order of basic strength of their conjugate base, i.e. ClO^- is the strongest base.

2.(B) $K_w = [H_3O^+][OH^-] = 10^{-6} \times 10^{-6} = 10^{-12}$

3.(D) No matter, what is the concentration of HCl, its pH will always be less than 7 at $25°C$. In the present case, the solution is very dilute, pH will be between 6 and 7.

4.(A) Acidic buffer is prepared by mixing weak acid with salt of its conjugate base. Therefore, acetic and sodium acetate can be used to prepare acidic buffer.

5 For acidic buffer, the Henderson's equation is

$$pH = pK_a + \log \frac{(\text{mole of salt})}{(\text{mole of acid})}$$

$$4.75 = -\log(1.34 \times 10^{-5}) + \log \frac{x}{0.02}$$

$\Rightarrow$ x = 0.015mole of sodium propionate.

Addition of 0.01 mole HCl increase moles of propinic acid by 0.01 and moles of sodium propionate will decrease by same amount.

New moles of acid = 0.02 + 0.01 = 0.03

$$pH = -\log\left(1.34 \times 10^{-5}\right) + \log\left(\frac{0.005}{0.030}\right) = 4.09$$

pH of 0.001 HCl = 2, just half of the pH of final buffer solution

6. Sodium acetate (CH_3COONa) is a basic salt (salt of strong base and weak acid) therefore, its aqueous solution has pH > 7.

7.(B) For precipitation reaction, $Q_{IP} > K_{sp}$

$$Q_{IP} = [Ca^{2+}][F^-]^2 = \left(\frac{10^{-2}}{2}\right) \times \left(\frac{10^{-3}}{2}\right)^2 = 1.25 \times 10^{-9} > K_{sp},\ \text{precipitate will be formed.}$$

8. mmol of NaOH $= 20 \times 0.2 = 4$

mmol of acetic acid $= 50 \times 0.2 = 10$

After neutralization, buffer solution is formed which contain 6 mmol CH_3COOH and 4 mmol CH_3COONa.

$$pH = pK_a + \log \frac{[CH_3COONa]}{[CH_3COOH]} = -\log\left(1.8 \times 10^{-5}\right) + \log \frac{4}{6} = 4.56$$

Now, let x mmol of NaOH is further added so that pH of the resulting buffer solution is 4.74.

Now, the buffer solution contains (4 + x) mmol CH_3COONa

$$4.74 = -\log(1.8 \times 10^{-5}) + \log \frac{4+x}{6-x}$$

$$\Rightarrow \quad \frac{4+x}{6-x} \quad \Rightarrow \quad x = 1.0\,\text{mmol} = 0.2 \times V \quad \Rightarrow \quad V = 5\text{mL of NaOH.}$$

9.(F) $AlCl_3$ is Lewis acid because it can accept lone pair of electrons

10. SO_4^{2-}

11. Molarity (C) = 0.10

$[H^+]\sqrt{K_a \cdot C} = 7 \times 10^{-5}$ M (α is negligible)

pH = 4.15

$$[OH^-] = \frac{K_w}{[H^+]} = \frac{10^{-14}}{7 \times 10^{-5}} = 1.43 \times 10^{-10} \text{ M}$$

12. $K_{sp}(AgI) = 8.5 \times 10^{-17} = [Ag^+][I^-]$

$[I^-]$ required to start precipitation of AgI $= \dfrac{8.5 \times 10^{-17}}{0.10} = 8.5 \times 10^{-16}$ M

$K_{sp} = (HgI_2) = 2.5 \times 10^{-26} = [Hg^{2+}][I^-]^2$

$[I^-]$ required to start precipitation of $HgI_2 = \sqrt{\dfrac{2.5 \times 10^{-26}}{0.10}} = 5 \times 10^{-13}$ M

The above calculation indicates that lower $[I^-]$ is required for precipitation of AgI. When $[I^-]$ reaches to 5×10^{-13}, AgI gets precipitated almost completely.

When HgI_2 starts precipitating.

$$[Ag^+] = \frac{8.5 \times 10^{-17}}{5 \times 10^{-13}} = 1.70 \times 10^{-4} \text{ M}$$

$$\% \text{ Ag}^+ \text{ remaining } = \frac{1.70 \times 10^{-4} \times 100}{0.10} = 0.17$$

% Ag^+ precipitated $= 100 - 0.17 = 99.83$

13. **(i)** $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$

$C(1-\alpha) \qquad C\alpha \qquad C\alpha$

If no HCl is present, $[HCl] = \dfrac{0.2}{2} = 0.10$ M

$[CH_3COOH] = 0.10$ M

The major contributor of H^+ in solution is HCl.

$$K_a = \frac{C\alpha(0.1)}{C(1-\alpha)} = 1.75 \times 10^{-5}$$

$\alpha = 1.75 \times 10^{-4} \quad (\because 1 - \alpha \simeq 1)$

(ii) mmol of NaOH added $= \dfrac{6}{40} \times 1000 = 150$

Mmol of HCl = $500 \times 0.2 = 100$

mmol of HCl $= 500 \times 0.2 = 100$

After neutralisation, mmol of $CH_3COOH = 50$

Mmol of $CH_3COONa = 50$

$pH = pK_a = 4.75$

14.(C) The reaction of HA with strong base is

$$HA + OH^- \rightleftharpoons H_2O + A^-$$

$$K = \frac{\left[A^-\right]}{[HA]\left[OH^-\right]} \times \frac{\left[H^+\right]}{\left[H^+\right]} = \frac{K_a}{K_w} = \frac{10^{-4}}{10^{-14}} = 10^{10}$$

15.(A) $K_a\left(HX\right) = \frac{K_w}{K_b} = 10^{-4}$

$$pH = pK_a + \log\frac{\left[X^-\right]}{\left[HX\right]}$$

$$\Rightarrow \quad pK_a = 4 \qquad \left[\because \left[X^-\right] = [HX]\right]$$