16.(D) pH = 1

$\therefore \quad [H^+] = 10^{-1} = 0.1\ M$

pH = 2

$\therefore \quad [H^+] = 10^{-2} = 0.01\ M$

For dilution of HCl, $M_1V_1 = M_2V_2$

$0.1 \times 1 = 0.01 \times V_2$

$V_2 = 10\ L$

Volume of water to be added $10 - 1 = 9 L$

17.(C) $HQ = H^+ + Q^-$

$[H^+] = \sqrt{K_aC}$ by Ostwald's dilution law

$[H^+] = 10^{-pH} = 10^{-3} M$

$C = 0.1\ M$

Thus, $10^{-3} = \sqrt{K_a \times 0.1}$

$10^{-6} = K_a \times 0.1$

$\therefore \quad K_a = 10^{-5}$

Alternation Method

$HQ \rightleftharpoons H^+ + Q^-$

Initial concentration 0.1 M 0 0

Given, pH = 3. This suggests $[H^+] = 10^{-3}$ M at equilibrium $= 10^{-3}$M.

Hence, $[HQ] = 0.1\ M - 10^{-3}\ M = 0.1\ M$ $[10^{-3}M <<< 0.1\ M]$

K_a for the above reaction is given by:

$$K_a = \frac{[H^+][Q^-]}{[HQ]} = \frac{[10^{-3}][10^{-3}]}{[0.1]}$$

$K_a = 1 \times 10^{-5}$

18.(C) $H_2A \rightleftharpoons HA^- + H^+$

$$\therefore \quad K_1 = 1.0 \times 10^{-5} = \frac{[H^+][HA^-]}{[H_2A]} \text{ (given)}$$

$HA^- \rightarrow H^+ + A^{2-}$

$$\therefore \quad K_2 = 5.0 \times 10^{-10} = \frac{[H^+][A^{2-}]}{[HA^-]} \text{ (given)}$$

$$K = \frac{[H^+]^2[A^{2-}]}{[H_2A]} = K_1 \times K_2 = (1.0 \times 10^{-5}) \times (5 \times 10^{-10}) = 5 \times 10^{-15}$$

19.(C) Let molar solubility of $Cr(OH)_3$ = S mol L^{-1}

$Cr(OH)_3(S) \rightleftharpoons Cr^{3+}_s(aq) + 3OH^-_{3s}(aq) \lim_{x\to\infty}$

$K_{sp} = 1.6 \times 10^{-30} = [Cr^{3+}][OH^-]^3 = (S)(3S)^3 = 27\ S^4$

$$\therefore \quad S^4 = \frac{1.6 \times 10^{-30}}{27} \quad \therefore \ S = \sqrt[4]{\frac{1.6 \times 10^{-30}}{27}}$$

20.(C) The pK_a values of HCO_3^-, H_3O^+ and HSO_4^- are 10.25, –1.74 and 1.92 respectively and HSO_3F is super acid. (iv) > (ii) > (iii) > (i)

21.(A) pH of a solution = 5

$\therefore \quad [H^+] = 10^{-pH} = 10^{-5}$

HA (a weak acid) ionizes as

$$HA \rightleftharpoons H^+ + A^-$$
$$1.0 \quad 0 \quad 0$$
$$(1-10^{-5}) \quad 10^{-5} \quad 10^{-5}$$

$$K_a \frac{[H^-][A^-]}{[HA]} = \frac{10^{-5}\times 10^{-5}}{(1-10^{-5})} = \frac{10^{-10}}{1}[1 >>> 10^{-5}] = 1\times 10^{-10}M$$

22.(A) Only in reaction (II), $H_2PO_4^-$, gives H^+ to H_2O. Thus, behaves as an acid.

23.(C) $H_2CO_3 \rightleftharpoons H^+ + HCO_3^-;\ K_1 = 4.2\times 10^{-7}$

$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-};\ K_2 = 4.8\times 10^{-11}$

$K_1 >> K_2$

$\therefore \quad [H^+] = [HCO_3^-]$

$$K_2 = \frac{[H^+][CO_3^{2-}]}{[HCO_3^-]}$$

So, $[CO_3^{2-}] = K_2 = 4.8\times 10^{-11}$

24. (B) $[AgBr] = [Ag^+] = 0.05$ M

$K_{sp}[AgBr] = [Ag^+][Br^-]$

$$\Rightarrow \quad [Br^-] = \frac{K_{sp}(AgBr)}{[Ag^+]} = \frac{5.0\times 10^{-13}}{0.05} = 10^{-11}M\ [mol\ L^{-1}]$$

Moles of KBr needed to precipitate AgBr $= [Br^-]\times V = 10^{-11}$ mol $L^{-1}\times 1$ L $= 10^{-11}$ mol

Therefore, amount of KBr needed to precipitate AgBr $= 10^{-11}$ mol $\times 120$ g $mol^{-1} = 1.2\times 10^{-9}$ g

25. (B) $Mg(OH)_2 \rightleftharpoons Mg^{2+} + 2OH^-$

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

$$[OH^-] = \sqrt{\frac{K_{sp}}{[Mg^{2+}]}} = \sqrt{\frac{1\times 10^{-11}}{0.001}} = 10^{-4}$$

$pOH = -\log[OH^-] = -\log[10^{-4}]$

$pOH = 4 \quad \therefore \quad pH = 14 - pOH = 14 - 4 = 10$

26.(D) $pH = 1 \quad \therefore \quad [H^+] = 10^{-1} = 0.1M$

$pH = 2 \quad \therefore \quad [H^+] = 10^{-2} = 0.01M$

For dilution of HCl, $M_1V_1 = M_2V_2$

$0.1\times 1 = 0.01\times V_2$

$V_2 = 10L$

Volume of water to be added $= 10 - 1 = 9L$

27. (B) $Na_2CO_3 \rightleftharpoons 2Na^+ + CO_3^{2-}$

$[Na_2CO_3] = [CO_3^{2-}] = 1 \times 10^{-4} M$

$BaCO_3 \rightleftharpoons Ba^{2+} + CO_3^{2-}$

$K_{sp(BaCO_3)} = [Ba^{2+}][CO_3^{2-}]$

$$[Ba^{2+}] = \frac{K_{sp}(BaCO_3)}{[CO_3^{2-}]}$$

$$[Ba^{2+}] = \frac{5.1 \times 10^{-9}}{1 \times 10^{-4}}$$

$[Ba^{2+}] = 5.1 \times 10^{-5}$ M

Hence, at 5.1×10^{-5} concentration of Ba^{2+}, a precipitate will begin to form.

28.(C) pH of a salt made up of weak acid and weak base is calculated by using expression

$$pH = 7 + \frac{1}{2}pK_a - \frac{1}{2}pK_b = 7 + \frac{3.2}{2} - \frac{3.4}{2} = 6.9$$

29.(D) CH_3COOK is a salt of a weak acid and a strong base

$\therefore$ Most basic

30.(A) Methyl orange is used for titration of strong acid and weak base.