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Deg - I (H) - Physical Chemistry
(Paper - II)

Chapter - Ionic Equilibrium

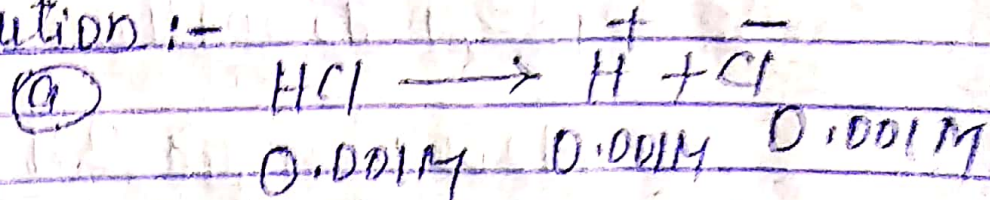
Topics - Numericals based
upon pH, pOH, pK_a & K_{sp}

Numerical - Based upon pH

① Calculate the pH of

- ① 0.001 M HCl ② 0.001 N H_2SO_4
③ 0.001 M H_2SO_4 ④ 0.01 M NaOH

Solution :-



Concentration of H^+ ion

$$[H^+] = 0.001M \\ = 10^{-3}M$$

$$\text{Thus } pH = -\log 10^{-3}$$

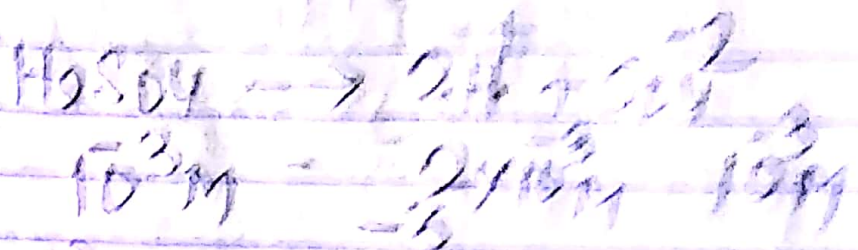
$$= -\times -3 \log 10$$

$$= 3 \times 1$$

$$pH = 3$$

$$\left| \log 10 = 1 \right|$$

(b) 0.001M H_2SO_4



$$[H^+] = 2 \times 10^{-3}$$

$$\text{Now, } pH = -\log 2 \times 10^{-3}$$

$$= -[\log 2 + \log 10^{-3}]$$

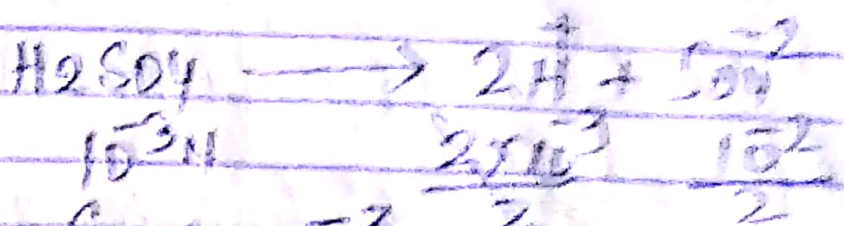
$$= -[0.30103 - 3 \log 10]$$

$$= -[0.30103 - 3]$$

$$= 2.6989 \text{ Ans.}$$

(c) 0.001N H_2SO_4

$10^{-3}N \ H_2SO_4$



$$[H^+] = 10^{-3}, \quad pH = 3$$

(d) 0.01M NaOH



$$p[OH] = -\log 10^{-2}$$

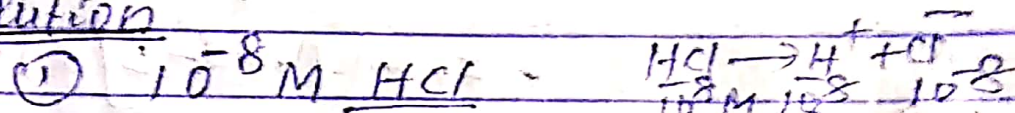
$$= -\log 10^{-2}$$

$$= 2$$

Now, $pH = 14 - p(OH)$
 $= 14 - 2$
 $= 12$

- ② Calculate pH of (a) $10^{-8} M$ HCl
 (ii) a solution obtained by mixing 50 ml of 0.2 N HCl with 50 ml of 0.1 N NaOH.

Solution



Some times pH of acid comes more than 7 as in above case. The solution is very dilute. In such case $[H^+]$ contribution from water is also considered.

Total $[H^+] = [H^+]$ from water + $[H^+]$ from Acid.

$= 10^{-7} + 10^{-8}$
 $= 1.1 \times 10^{-7}$

$pH = -\log(1.1 \times 10^{-7})$

$= -[\log 1.1 + \log 10^{-7}]$

$= -[0.04 - 7] = 7 - 0.04 = 6.96$

(ii) Number of milli equivalent of acid
 $= 50 \times 0.2 = 10 \text{ ml N}$

Number of milli equivalent of base
 $= 50 \text{ ml} \times 0.1 N$
 $= 5 \text{ ml N}$

Acid left after mixing.

$= (10 - 5) = 5 \text{ ml}$

Total volume of the solution

$$[H^+] = \frac{5}{1000} \times 10^{-3} = 5 \times 10^{-3} = 0.005 M$$

$$\begin{aligned} \therefore pH &= -\log 0.005 \\ &= -\log 5 \times 10^{-3} \\ &= -\{\log 5 + \log 10^{-3}\} \\ &= -[0.70 - 3] = 2.3 \text{ Ans} \end{aligned}$$

(c)

Given: Buffer soln

Calculate pH of buffer solution prepared by mixing 10 ml 0.1 M CH_3COOH and 20 ml of 0.1 N CH_3COONa .
 $pK_a(CH_3COOH) = 4.74$

~~Soln~~ No. of moles of $CH_3COOH = \frac{0.1 \times 10}{1000}$

$$\begin{aligned} \text{No. of moles of } CH_3COONa &= 0.001 \\ &= \frac{0.1 \times 20}{1000} = 0.002 \end{aligned}$$

$$pH = pK_a + \log \frac{[Salt]}{[Acid]}$$

$$= 4.74 + \log \frac{0.002}{0.001}$$

$$= 4.74 + \log 2$$

$$= 4.74 + 0.30103$$

$$= 5.04$$

(d) Yps Solubility Product

The solubility product of BaSO_4 is 1.5×10^{-9}

Find sol. the solubility in

(a) pure water

(b) 0.1M BaCl_2

Solution



Let s be the solubility of BaSO_4 in mol/l^{-1} then

$$K_{sp} = [\text{Ba}^{2+}] [\text{SO}_4^{2-}]$$

$$1.5 \times 10^{-9} = s \times s = s^2$$

$$\text{So, } s = \sqrt{1.5 \times 10^{-9}}$$

$$= 3.87 \times 10^{-5} \text{ mol/l}$$

(b) Let s' be the solubility of BaSO_4 in 0.1M BaCl_2 solution.

$$\begin{aligned} \text{Total } [\text{Ba}^{2+}] \text{ ions} &= (s' + c) \text{ mol/l} \\ [\text{SO}_4^{2-}] &= s' \text{ mol/l} \end{aligned}$$

$$K_{sp} = (s' + c) \times s'$$

$$1.5 \times 10^{-9} = (s')^2 + 0.1s'$$

$$s' = \frac{1.5 \times 10^{-9}}{0.1} = 1.5 \times 10^{-8}$$

$$\text{mol/l}$$