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

Chapter - Ionic - Equilibrium

Topics - Numericals based upon pH, p(OH), pKw & Ksp

Numerical - Based upon pH.

(1) Calculate the pH of.

(a) 0.001 M HCl (c) 0.001 N H_2SO_4
(b) 0.001 M H_2SO_4 (d) 0.01 M NaOH

Solution :-

(a)
$$HCl \longrightarrow H^+ + Cl^-$$
$$0.001M \quad 0.001M \quad 0.001M$$

Concentration of H^+ ion

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

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

$$= -\times -3 \log 10 \qquad \log 10 = 1$$
$$= 3 \times 1$$
$$\boxed{pH = 3.}$$

(b) 0.001M H_2SO_4

$H_2SO_4 \rightarrow 2H^+ + SO_4^{-2}$

$10^{-3}M \quad 2\times10^{-3}M \quad 10^{-3}M$

$[H^+] = 2\times10^{-3}$

Now, $pH = -\log 2\times10^{-3}$

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

$= -[0.30103 - 3\log_{10} 10]$

$= -[0.30103 - 3]$

$= 2.698$ Ans.

(c) $0.001N H_2SO_4$

$10^{-3}N \; H_2SO_4$

$H_2SO_4 \longrightarrow 2H^+ + SO_4^{-2}$

$10^{-3}N \quad \frac{2\times10^{-3}}{2} \quad \frac{10^{-3}}{2}$

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

(d) 0.01M NaOH

$10^{-2}M \; NaOH \longrightarrow Na^+ + OH^-$

$10^{-2} \quad 10^{-2}$

$p(OH) = -\log OH^-$

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

$= 2$

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

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

Solution

(i) 10^{-8} M HCl. $\underset{10^{-8}M}{HCl} \rightarrow \underset{10^{-8}}{H^+} + \underset{10^{-8}}{Cl^-}$

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.

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

$pH = -\log(1.1 \times 10^{-7})$
$= -[\log 1.1 + \log 10^{-7}]$
$= -[0.04 - 7] = 7 - 0.04 = 6.96$ Ans

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

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

Acid left after mixing
$= (10 - 5) = 5$ml

Total volume of the solution

$= 50 + 50 = 100\ ml$

$[H^+] = \frac{5}{1000} \times 1000 \times 10^{-3} = 5 \times 10^{-2}$

$= 0.05\ M$

$\therefore pH = -\log 0.05$

$= -\log 5 \times 10^{-2}$

$= -\{\log 5 + \log 10^{-2}\}$

$= -[0.70 - 2] = 1.3$ Ans

(C) Upon- Buffer sol.

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

$pKa(CH_3COOH) = 4.74$

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

$= 0.001$

No of moles of CH_3COONa

$= \frac{0.1 \times 20}{1000} = 0.002$

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

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

$= 4.74 + \log 2$

$= 4.74 + 0.30103$

$= 5.04$

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4 par. Solubility product

(d) The solubility product of $BaSO_4$ is 1.5×10^{-9}

Find out the solubility in
(a) pure water
(b) 0.1M $BaCl_2$

Solution

(a) $BaSO_4 \rightleftharpoons Ba^{+2} + SO_4^{-2}$

let S be the solubility of $BaSO_4$ in $mol\,L^{-1}$ then

$$K_{sp} = [Ba^{+2}][SO_4^{-2}]$$

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

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

$$= 3.87 \times 10^{-5}\ mol\,L^{-1}$$

(b). let S' be the solubility of $BaSO_4$ in 0.1M $BaCl_2$ solution.

Total $[Ba^{+2}]$-ions $= (S' + C)\ mol\,L^{-1}$

$[SO_4^{-2}] = S\ mol/lit.$

$$K_{sp} = (S' + C) \times S'$$

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

$$S' = \frac{1.5 \times 10^{-9}}{0.1} = 1.5 \times 10^{-8}\ mol/L$$

neglect $(S')^2$