Ques1 :— Calculate the p^H of

(a) 10^{-4} M HCl

(b) 0.002 M HNO_3

(c) 10^{-3} M H_2SO_4

Ans-1 (a) $HCl \rightleftharpoons H^+ + Cl^-$ [strong acid completely dissociates]

10^{-4} M $\quad 10^{-4} \quad 10^{-4}$

$[H^+] = 10^{-4}$ M $= 10^{-4}$ moles/litre

$pH = -\log[H^+] = -\log 10^{-4} = 4$

$pH = 4$

$pH + pOH = 14 \Rightarrow pOH = 14 - pH$

$pOH = 14 - 4 = 10$

(b) 0.002 M HNO_3

$HNO_3 \rightleftharpoons H^+ + NO_3^-$

$0.002 \quad 0.002 \quad 0.002$

$[H^+] = 0.002$ M

$pH = -\log[H^+] = -\log 0.002$

$= 2.699$

(c) $H_2SO_4 \rightleftharpoons 2H^+ + SO_4^{--}$ [10^{-3} M H_2SO_4]

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

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

$= 2.699$

Ques2. Calculate the hydrogen ion concentration of a solution of pH 5.4.

Ans- $pH = -\log[H^+] = 5.4$

$\log[H^+] = -5.4$

$[H^+] = \text{Antilog}(-5.4)$

$= 3.98 \times 10^{-6}$ mole/litre.

Ques3 - Calculate pH of

(a) 10^{-4} M NaOH

(b) 3.2×10^{-3} M $Ba(OH)_2$

Ans 3 (a) $NaOH \rightleftharpoons Na^+ + OH^-$

$[OH^-] = 10^{-4}$ M

$pOH = -\log[OH^-] = -\log(10^{-4}) = 4.0$

$\Rightarrow pH + pOH = 14$

$pH + 4 = 14$

$pH = 10.0$

(b) 3.2×10^{-3} M $Ba(OH)_2$

$Ba(OH)_2 \rightleftharpoons Ba^{2+} + 2OH^-$

$[OH^-] = 2 \times 3.2 \times 10^{-3} = 6.4 \times 10^{-3}$ M

$pOH = -\log[OH^-] = -\log(6.4 \times 10^{-3})$

$= -\log 6.4 - \log 10^{-3}$

$= -0.8062 - (-3)$

$= 0.8062 + 3 = 2.19$

$pH = 14 - pOH = 14 - 2.19$

$= 11.81.$

Ques4: Calculate H^+ & OH^- concentration of a NaOH solution whose pH is 10.0.

Ans - $pH = 10.0 = -\log[H^+]$

$\log[H^+] = -10.0$

$[H^+] = \text{Antilog}(10.0)$

$= 10^{-10}$ mole/litre

we know $[H^+] \times [OH^-] = 10^{-14} \Rightarrow [OH^-] = \frac{10^{-14}}{[H^+]}$

$[OH^-] = \frac{10^{-14}}{10^{-10}}$

$[OH^-] = 10^{-4}$ mole/litre.

Ques 5:- Calculate the pH of a solution obtained by mixing 50 ml of 0.2M HCl with 50 ml of 0.1M NaOH.

Ans:- 1000 ml of HCl solution contains = 0.2 moles of HCl

50 " " " " " $= \frac{0.2}{1000} \times 50 = 0.01$ moles

1000 ml of NaOH solution contains = 0.1 moles of NaOH.

50 " " " " " $= \frac{0.1}{1000} \times 50 = 0.005$ moles

When we mix HCl & NaOH.

$HCl + NaOH \longrightarrow NaCl + H_2O$ (Neutralization reaction)

Number of moles of HCl left after addition of NaOH = 0.01 − 0.005
= 0.005 moles

Total volume of solution = 50 + 50 = 100

Conc. of HCl = 0.005 moles/100 ml
= 0.05 moles/1000 ml or 0.05 moles/litre

$[H^+] = 0.05 \Rightarrow pH = -\log(0.05)$
$= 1.30.$

Ques 6:- Calculate the pH of an aqueous solution obtained by mixing 25 ml of 0.2 HCl with 50 ml of 0.25 M NaOH.

Ans:- 1000 ml of HCl soln contains = 0.2 moles of HCl.

25 " " " " " $= \frac{0.2}{1000} \times 25 = 0.005$

50 " " NaOH " " $= \frac{0.25}{1000} \times 50 = 0.0125$ moles.

Number of moles of NaOH left after adding HCl = 0.0125 − 0.005
= 0.0075

Total volume of solution = 25 + 50 = 75 ml.

Conc of NaOH = 0.0075 moles/75 ml

= 0.1 mole/litre

$[OH^-] = 0.1$ M

$pH = -\log[OH^-] = -\log 0.1$
$= 1$

$pH = 14 - pH = 14 - 1 = 13.$

75 ml — 0.0075 moles

1 " — $\frac{0.0075}{75}$ "

1000 " — $\frac{0.0075}{75} \times 1000$

$= 0.1$

Ques → Calculate pH of

(a) 10^{-7} M HCl (b) 10^{-8} M HCl (c) 10^{-6} M NaOH

(d) 2×10^{-7} M $Ba(OH)_2$.

Ans – (a) Since [HCl] is less than 10^{-6} M, so dissociation of water is also considered.

$$HCl \rightleftharpoons H^+ + Cl^-$$
$$10^{-7} \qquad 10^{-7} \qquad 10^{-7}$$

$$H_2O \rightleftharpoons H^+ + OH^-$$
$$x \qquad x$$

Total $[H^+] = x + 10^{-7}$

" $[OH^-] = x$

$\Rightarrow [H^+][OH^-] = 10^{-14} \Rightarrow (x+10^{-7})\,x = 10^{-14}$

$x^2 + 10^{-7}x - 10^{-14} = 0 \Rightarrow x = 0.62\times10^{-7}$ mole/l

Total $[H^+] = x + 10^{-7} = 0.62\times10^{-7} + 10^{-7}$

$= 1.62\times10^{-7}$

$pH = -\log(1.62\times10^{-7}) = 6.79$ (less than 7.0)

(c) $$NaOH \rightleftharpoons Na^+ + OH^-$$
$$10^{-6} \qquad 10^{-6} \qquad 10^{-6}$$

$$H_2O \rightleftharpoons H^+ + OH^-$$
$$x \qquad x$$

Total $[H^+] = x$, Total $[OH^-] = x + 10^{-6}$

$[H^+][OH^-] = 10^{-14} \Rightarrow x(x+10^{-6}) = 10^{-14}$

$\Rightarrow x^2 + 10^{-6}x - 10^{-14} = 0$

$\Rightarrow x =$

$[H^+] = x =$

$pH = -\log[H^+] =$

Ques:- Calculate the pH of a HCl soln, whose strength is 3.65×10^{-3} gram/litre.

Ans:-

$$HCl = 3.65 \times 10^{-3} \text{ gram/litre}$$

$$= \frac{3.65 \times 10^{-3}}{36.5} \text{ mole/litre}$$

$$= 10^{-4} \text{ mole/litre}$$

$$[H^+] = 10^{-4} \text{ M}$$

$$pH = -\log 10^{-4} = 4.0$$

Ques:- Calculate pH of 100 ml of H_2SO_4 soln which contains 9.8×10^{-4} grams of ~~NaOH~~ H_2SO_4.

Ans →

$$H_2SO_4 = 9.8 \times 10^{-4} \text{ gram/100 ml}$$

$$= 9.8 \times 10^{-3} \text{ gram/1000 ml}$$

$$= \frac{9.8 \times 10^{-3}}{98} \text{ mole/litre}$$

$$H_2SO_4 = 1 \times 10^{-4} \text{ mole/litre}$$

$$[H^+] = 2 \times 10^{-4}$$

$$pH = -\log 2 \times 10^{-4}$$

$$pH = 3.69.$$

Buffer Solution

Ques-1:- A buffer solution containing 0.15 moles of acetic acid and 0.20 moles of sodium acetate per litre. Calculate the pH of the solution. Dissociation constant of acetic acid at Room temp is 1.75×10^{-5}.

Ans →

$[CH_3COOH]$ = 0.15 moles/litre — [Acid]

$[CH_3COONa]$ = 0.20 " " — [Salt]

$K_a = 1.75 \times 10^{-5}$

[Acidic buffer]

$$pH = p^{K_a} + \log \frac{[Salt]}{[Acid]}$$

$$= -\log K_a + \log \frac{[Salt]}{[Acid]}$$

$$= -\log(1.75 \times 10^{-5}) + \log \frac{0.20}{0.15}$$

$$= 4.76 + 0.124$$

$$= 4.884.$$

Ques 2. A buffer solution contains 0.20 mole of NH_4OH & 0.25 moles of NH_4Cl per litre. Calculate the pH of the solution.
Given $K_b = 1.81 \times 10^{-5}$

Ans:- $[NH_4OH] = [Base] = 0.20$ moles/litre

$[NH_4Cl] = [Salt] = 0.25$ " "

[Basic buffer]

$$p^{OH} = p^{K_b} + \log \frac{[Salt]}{[Base]}$$

$$p^{OH} = -\log K_b + \log \frac{[Salt]}{[Base]}$$

$$= -\log 1.81 \times 10^{-5} + \log \frac{0.25}{0.20}$$

$$= 4.742 + 0.097$$

$$= 4.839$$

$$pH = 14 - p^{OH} = 14 - 4.839$$

$$pH = 9.161$$

Ques 3 :- What would be the pH of an aqueous soln obtained by mixing 5 gram of CH_3COOH & 7.5 gram of CH_3COONa and making the volume equal to 500ml.
Ka of CH_3COOH is 1.75×10^{-5}.

Ans:- $[CH_3COOH] = \frac{5 \text{ gram}}{500 \text{ ml}} = \frac{5}{60} \times \frac{1000}{500}$ mole/litre.

$[CH_3COONa] = \frac{7.5 \text{ gram}}{500 \text{ ml}} = \frac{7.5}{82} \times \frac{1000}{500}$ " "

$$pH = -\log(1.75 \times 10^{-5}) + \log \frac{\frac{7.5}{82} \times \frac{1000}{500}}{\frac{5}{60} \times \frac{1000}{500}}$$

$pH = 4.80$.

Ques 4: A buffer solution contains 0.2 moles of CH_3COOH & 0.25 mole of CH_3COONa per litre. Calculate the change in pH after the addition of 0.0005 moles of HCl to buffer solution.
$K_a = 1.75 \times 10^{-5}$ (CH_3COOH)

Ans :- pH of solution before adding HCl.

$$pH = -\log(1.75 \times 10^{-5}) + \log \frac{0.25}{0.20}$$

$pH = 4.8569$.

The H^+ produced by HCl will combine with CH_3COO^-

$$H^+ + CH_3COO^- \longrightarrow CH_3COOH.$$

After adding HCl

$[CH_3COOH] = 0.20 + 0.0005 = 0.2005$ mle
$[CH_3COONa] = 0.25 - 0.0005 = 0.2495$ mle

$$pH = -\log(1.75 \times 10^{-5}) + \log \frac{0.2495}{0.2005}$$

$pH = 4.8549$.

Change in $pH = 4.8569 - 4.8549 = 0.002$.

Ques 5:- Calculate the pH before & after the addition of 0.0004 moles of NaOH of 1 litre of buffer solution which contains 0.20 moles of CH_3COOH & 0.25 moles of ~~Na~~ CH_3COONa.
$K_a = 1.75 \times 10^{-5}$ $[CH_3COOH]$.

Ques 5:- Calculate the pH before and after the addition of 0.01 mole of NaOH to 1 litre of buffer solution that is 0.1M NH_4OH & 0.1M NH_4Cl.

K_b of $NH_4OH = 1.81 \times 10^{-5}$.

Ans:- pH of soln before adding NaOH.

$$pOH = -\log 1.81 \times 10^{-5} + \log \frac{0.1}{0.1}$$

$$= 4.7423. \quad \Rightarrow \quad pH = 9.2577$$

after adding NaOH, the OH^- of NaOH will combine with NH_4^+

$$NH_4^+ + OH^- \Rightarrow NH_4OH.$$

After adding NaOH.

$$[NH_4OH] = 0.1 + 0.01 = 0.11$$

$$[NH_4Cl] = 0.1 - 0.01 = 0.09.$$

$$pH = -\log(1.81 \times 10^{-5}) + \log \frac{0.09}{0.11}$$

$$= 4.7423 + (-0.0872) \quad (-0.0872)$$

$$pOH = 4.6551$$

$$pH = 9.3349 \quad [\text{Slight increase in } pH]$$

Ques 6:- Calculate the change in pH after the addition of 0.003 mole of HCl to 1 litre of buffer soln which contains 0.2 moles of NH_4OH & 0.25 mole of NH_4Cl.

K_b of $NH_4OH = 1.81 \times 10^{-5}$.