pH of solution:

- scale to measure H^+ - ion concentration in a solution.
- value of pH decides the acidic or basic behaviour of solution.

$$0 \xleftarrow{\text{ACIDIC}} \underset{\text{(NEUTRAL)}}{7} \xrightarrow{\text{BASIC}} 14$$

- pH of solution can be calculated as:

$$\boxed{pH = -\log H^+} \qquad H^+ = 10^{-pH}$$

$$\boxed{K_w = [H^+][OH^-] = 10^{-14}}$$

$$\boxed{p^{K_w} = p^H + p^{OH} = 14}$$

a) Calculation of pH for strong acid:

Q:3 find pH for: (a) 0.01 M HCl (b) 0.05 M H_2SO_4

(c) 0.02 M H_3PO_4 (d) 0.03 M H_3PO_2

(e) 10^{-8} M HCl. (f) 10^{-6} M HCl

→ $\boxed{(a)}$ 0.01 M HCl.

$H^+ = 0.01 = 10^{-2}$

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

$= 2 \cancel{\log 10}^{\to 1}$

$= \underline{2}$.

$\boxed{(b)}$ 0.05 M H_2SO_4. $(2H^+ + SO_4^{2-})$

∴ $H^+ = 2 \times 0.05 = 0.1 = 10^{-1}$

$pH = -\log 10^{-1}$

$= 1 \cancel{\log 10}^{\to 1}$

$= \underline{1}$.

2.00
.47
53

0.778
2
PAGE NO.: 1 2

#

$\boxed{(c)}$ 0.02M H_3PO_4

$H^+ = 3 \times 0.02 = 0.06$

$pH = -\log(6\times10^{-2})$.

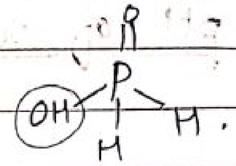
$= -(\log(6) + \log 10^{-2})$

$= -(0.778 + (-2))$

$= -(-1.222)$

$= \underline{1.22}$

$\boxed{(d)}$ 0.03M H_3PO_2



$H^+ = 1$.

$\therefore H^+ = 0.03M = 3\times10^{-2}$

$pH = -\log(3\times10^{-2})$.

$= -(\log(3) + \log(10)^{-2})$

$= -(0.47 + (-2))$.

$= -(-1.53) = \underline{1.5}$.

very diluted

$\boxed{(e)}$ 10^{-8}M HCl of H_2O

$H^+ = 10^{-8} + 10^{-7}$

$pH = -\log(10^{-8}+10^{-7})$.

$= -\log 10^{-8}(1+10)$.

~~$= -\log 10^{-8}(11)$.~~

$= -(\log(10^{-8}) + \log(11))$

$= -(-8 + 1.04)$

$= \underline{6.96}$.

$\boxed{f}$ 10^{-6}M HCl. H_2O

$H^+ = 10^{-6} + 10^{-7}$

$pH = -\log(10^{-6}+10^{-7})$

$= -\log 10^{-7}(10+1)$.

$= -(-7 + 1.04)$.

$= \underline{5.96}$.

NOTE:
- if concentration of H^+ ion is from 10^{-6} to 10^{-8} M than add number of H^+ ion to water (10^{-7}).

b.) pH for strong base:

Same

Q:4 find pH of: (a) 0.04M NaOH (b) 0.02M $Ca(OH)_2$.

$\boxed{(a)}$ 0.04M NaOH.

$OH^- = 4\times10^{-2}$.

$pH = -\log(4\times10^{-2})$.

$= -(\log(4) + (-2)\log(10))$

$= -(0.602 - 2) = \boxed{1.398}$

$pH + pOH = 14$.

$p = 14 - 1.398$

$= \underline{12.602}$

2.000
.602
1.398

PAGE NO.:

Sol^n	pH	pOH^-	pH^+
- 0.01M HCl	2	12	
- 0.05M H_2SO_4	1	13	
- 0.04M NaOH	12.6	1.40	
- 0.02M $Ca(OH)_2$	12.6	1.40	

C.) calculate pH for mixing of strong acids:

- final concentration of mixing solution can be calculated as:

$$N_1V_1 + N_2V_2 = N_3(V_1+V_2) \quad (\because N = m \times n)$$

$$M_1 \cdot n_1 \cdot V_1 + M_2 \cdot n_2 \cdot V_2 = M_3(V_1+V_2)$$

$$\boxed{M_3(H^+) = \frac{M_1 \cdot V_1 \cdot n_1 + M_2 \cdot V_2 \cdot n_2}{V_1+V_2}}$$

Q:5 0.01M HCl (50ml) mix to 0.02M H_2SO_4 (50ml) find out the pH of mixture.

$\leftrightarrow$ $HCl + H_2SO_4 \longrightarrow 3H^+ + SO_4^{2-} + Cl^-$

$$\Rightarrow \frac{[(0.01)*(1)*(50)] + [(0.02)\times(2)\times(50)]}{50+50} = H^+$$

$$H^+ = \frac{\boxed{0.5} + \boxed{2}}{100} \qquad H^+ = \frac{2.5}{100} \Rightarrow 25\times10^{-3}.$$

$\log 25 = \log(5\times5)$
$\{\log(a\times b) = \log(a+b)\}$
$= 0.7 + 0.7$
$= 1.4$

$$pH = -\log(25\times10^{-3})$$
$$= -[\log(25) + (-3)\log(10)]$$
$$= -[1.4 - 3]$$
$$= \underline{1.6}$$

$$pOH = 14 - 1.6$$
$$= \underline{13.4}.$$

d.) pH for mixing of strong base:

$$\boxed{[OH^-] = \frac{M_1 \cdot n_1 \cdot V_1 + M_2 \cdot n_2 \cdot V_2}{V_1 + V_2}}$$

Q:6 0.03M $Ca(OH)_2$ (100ml) mixed to 0.04M KOH (100ml). pH.

→ $[OH^-] = \frac{[(0.03)(2)(100)] + [(0.04)(100)(1)]}{100 + 100}$

$= \frac{[6]+[4]}{200} = \frac{10}{200}$ 0.05 $= 5 \times 10^{-2}$

pH $= -\log(5 \times 10^{-2})$
$= -(\log(5) + \log(10^{-2}))$
$= -[0.7 - 2]$
$= 1.3$

pH = 14 − 1.3
$\boxed{= 12.7}$

c.) pH of solution after dilution:

- after adding water in concentrated solution, the final concentration is calculated as:

$$N_1 V_1 = N_2 V_2 \qquad (\because N = m \times n)$$

$$\boxed{M_2 = \frac{M_1 \cdot n_1 \cdot V_2}{V_1 + V_2}}$$

Q:7 pH of 0.05M HCl (50ml) after adding 150ml H_2O.

→ $M_2 = \frac{(0.05)(1)(50)}{200}$ → $\frac{25}{2000}$ 80 $\frac{1}{80}$

$= \frac{\cancel{25}}{10 \times \cancel{200}_{4}}$ → $\cancel{25}\times 10^{-2}$ $= 12.5 \times 10^{-3}$

PAGE NO.:

$pH = -\log(25\times10^{-2})$ $pOH = 14 - 0.6$
$= 2 - 1.4$ $= \underline{13.4}$.
$= \underline{0.6}$.

$pH = -\log(12.5\times10^{-3})$
$= 3 - (\log(4) + \log(3))$
$= 3 - 1.1$
$= \underline{1.9}$

$pOH = 14 - 1.9$
$= \underline{12.1}$.
$(\log 12) = (\log(4\times3))$
$= \log(4) + \log(3)$
$= 0.602 + 0.477$

f) pH for mixing of strong acid with strong base:

$$N_1V_1 - N_2V_2 = N_3V_3$$

$$\boxed{N_3 = \frac{N_1V_1 - N_2V_2}{V_1+V_2}}$$

$$\boxed{M_3 = \frac{M_1V_1n_1 - M_2V_2n_2}{V_1+V_2}}$$

Acid + Base $\longrightarrow$ Salt + Water

if $[H^+] = [OH^-] \longrightarrow pH = 7$ (neutral)
if $[H^+] > [OH^-] \longrightarrow pH < 7$ (acidic) then find pH^+
if $[OH^-] > [H^+] \longrightarrow pH > 7$ (basic) then find pOH

Q.8 0.01M HNO_3 (100ml) reacts to 50ml of 0.02M NaOH. Find pH.
$\rightarrow$ $M_1n_1V_1 = 100 \times 0.01 \times 1$ $M_2n_2V_2 = 50 \times 0.02 \times 1$
$(H^+) = \underline{1}$ $(OH^-) = \underline{1}$.

$[H^+] = [OH^-] \longrightarrow \therefore pH = 7$.
(neutral)

Q:9 0.01 M NaOH (50ml) reacts (50ml) 0.05M HCl.

$\rightarrow$ $M_1 n_1 V_1 = (0.05)(50)(1)$ $\qquad$ $M_2 n_2 V_2 = (50)(0.01)(1)$

$(H^+) = \underline{2.5}$ $\qquad$ $(OH^-) = \underline{0.5}$.

$$M_3 = \frac{2.5 - 0.5}{100} = \frac{2}{100} \quad \underline{2 \times 10^{-2}}.$$

$pH = -\log(2 \times 10^{-2})$
$= 2 - 0.301$
$= \underline{1.7}$

$[H^+] > [OH^-]$
$= \underline{\text{acidic}}$.

Q:10 0.04M KOH (50ml) + (50ml) 0.01 M H_2SO_4

$\rightarrow$ $M_1 n_1 V_1 = (0.01)(50)(2)$ $\qquad$ $M_2 n_2 V_2 = (0.04)(\cancel{1})(5)$

$(H^+) = \underline{1}$ $\qquad$ $(OH^-) = \underline{2}$.

$$M_3 = \frac{2-1}{100} = \underline{1 \times 10^{-2}}.$$

$pOH = -\log(1 \times 10^{-2})$
$= 2 - 0$
$= \underline{2}$

$pH = 14 - 2$
$= \underline{12}$

$[OH^-] > [H^+]$
$= \underline{\text{basic}}$.

☆ g.) for weak acid:

$$CH_3COOH\,(aq) \rightleftharpoons CH_3COO^-(aq) + H^+(aq).$$

C	0	0
$C - C\alpha$	$C\alpha$	$C\alpha$

$\boxed{H^+ = C\alpha} \longrightarrow \boxed{H^+ = \sqrt{Ka \times C}}$ or $\boxed{H^+ = (Ka \times C)^{1/2}}$.

$-\log H^+ = -\log (Ka \times C)^{1/2}$ ∴ $\boxed{pH = \frac{1}{2}\left[\underbrace{-\log Ka}_{pKa} - \log Ca\right]}$

Q:11 pH of 0.15M solution of HOCl $(K = 9.6 \times 10^{-6})$.

$= 96 \times 10^{-7}$

→ $C = 15 \times 10^{-2}$.

mod:12

$H^+ = \sqrt{K \times C} \longrightarrow \sqrt{96 \times 10^{-7} \times 15 \times 10^{-2}}$

$\longrightarrow \sqrt{16 \times \cancel{6} \times 3 \times 5 \times 10^{-9}}$

$\longrightarrow 4\sqrt{2 \times 3 \times 3 \times 5 \times 10^{-9}} \rightarrow 12\sqrt{10 \times 10^{-9}}$ $\sqrt{10^{-8}}$

$= \underline{12 \times 10^{-4}}$.

$pH^+ = -\log (12 \times 10^{-4})$. $(\log 4 = 0.602)$

$= -[\log 4 + \log 3] + 4$. $(\log 3 = 0.47)$

$= (-1.07) + 4$

$(= 2.93)$

Q:12 K for 10^{-2}M HCN with OH = 10. $pH = 14 - 10 = \underline{4}$.

→ $pH = -\log[H^+]$

mod:13

$4 = -\log[H^+]$

$\frac{4}{\log} = [H^+]$ ∴ $\underline{H^+ = 10^{-4}}$.

$H^+ = \sqrt{K \times C}$. $\longrightarrow (K = 10^{-6})$

$(10^{-4})^2 = K \times 10^{-2}$

$\frac{10^{-8}}{10^{-2}} = K$

$10^{-8+2} = K$

$10^{-6} = K$.

Scanned with Oken Scanner

PAGE NO.:

Q:13 $K_a = 4\times10^{-10}$ of HCN $C = 2.5\times10^{-1}$. $= 25\times10^{-2}$.

→ $H^+ = \sqrt{4\times10^{-10}\times25\times10^{-2}}$

$= 2\times5\sqrt{10^{-12}} \longrightarrow 10\times10^{-6} = \underline{10^{-5}}$.

$pH = -\log(10^{-5})$.

$= \underline{\underline{5}}$.

Q:14 calculate pH and Ka of 10^{-2} M CH_3COOH (acetic acid) sol^n which is 4% ionised.

→ $\alpha = 0.04$. $C = 10^{-2}$. $\therefore H^+ = C\alpha$.

$= \underline{4\times10^{-4}}$.

$pH = -\log(4\times10^{-4})$.

$= 4 - 0.602$

$= \boxed{3.398.}$

$(H^+) = \sqrt{K\times C}$.

$(16\times10^{-4})^2 = K_a\times10^{-2}$.

$K_a = 16\times10^{-8+2}$

$\boxed{= 16\times10^{-6}}$

☆ (h.) mixing of weak acid:

$$\boxed{H^+ = \sqrt{K_{a_1}C_1 + K_{a_2}C_2 + \ldots + K_{a_n}C_n}}$$

PAGE NO.:

☆(i) for weak base:

$$NH_4OH(aq) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

C	0	0
$C - C\alpha$	$C\alpha$	$C\alpha$

$$\boxed{[OH^-] = C\alpha} \longrightarrow \boxed{pOH = \frac{1}{2}\left[\underbrace{-\log K_b}_{pK_b} - \log C\right]}$$

Q:15 pH for 0.2M NH_4OH having $pK_b = 3$

$\rightarrow$ $pOH = \frac{1}{2}\left[-(-3). - \underbrace{\log(2\times10^{-1})}\right]$

$-(\log(2)+\log(10^{-1}))$

$-(0.302 - 1) = 0.698$

$= \frac{1}{2}[3 + 0.698]$

$= \frac{1}{2}(3.698) \longrightarrow 1.849$

$pH = 14 - 1.849 \longrightarrow 12.151$