$K_b = \alpha^2$

hydrazine

PROBLEM 2 *0.16 g of N_2H_4 are dissolved in water and the total volume made upto 500 mL. Calculate the percentage of N_2H_4 that has reacted with water in this solution. The K_b for N_2H_4 is 4.0×10^{-6} M.*

(Roorkee 1998)

$N_2H_4 + H_2O \rightleftharpoons N_2H_5^+ + OH^-$

$K_b = 4 \times 10^{-6}$

$w = \frac{0.16}{32}$

$M = \frac{0.16}{32} \times \frac{1000}{500}$

$2NH_3 \rightleftharpoons NH_4^+ + NH_2^-$

$K = [NH_4^+][NH_2^-]$ ✓

PROBLEM 9 *Liquid ammonia ionises to a slight extent. At −50°C, its ionisation constant, $K_{NH_3} = [NH_4^+][NH_2^-] = 10^{-30}$. How many amide ions, are present per cm^3 of pure liquid ammonia? Assume $N = 6.0 \times 10^{23}$*

$[NH_2^-] = \sqrt{K} = 10^{-15}\,M$ ✓

$10^3\,ml$ — $10^{-15} \times 6 \times 10^{23}$

$1\,ml$ — 6×10^5

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$HCl > CHCl_2COOH > CH_3COOH$

PROBLEM 23 *A solution contains 0.09 M HCl, 0.09 M $CHCl_2COOH$ and 0.1 M CH_3COOH. The pH of this solution is 1. If K_a for acetic acid is 10^{-5}, calculate K_a for $CHCl_2COOH$.*

$HCl \rightarrow H^+ + Cl^-$

0.09 0.09

$CHCl_2COOH \rightleftharpoons CHCl_2COO^- + H^+$

	$CHCl_2COOH$	$CHCl_2COO^-$	H^+
$t=0$	0.09	0	$+0.09$
$t=eq$	$0.09-x$	x	$0.09+x$

$[H^+] = 0.1$

$0.09 + x = 0.1$

$K = \dfrac{(0.09+x)x}{0.09-x}$

PROBLEM 34 *Calculate the pH of solution obtained by mixing 10 mL of 0.1 M HCl and 40 mL of 0.2 M H_2SO_4.*

$HCl = 10 \times 0.1 = 1 \text{ mmol} = 1 \text{ meq}$

$H_2SO_4 = 40 \times 0.2 \times 2 = 16 \text{ meq}$

$= 17$

$\text{Meq} = N \times V_T$

$17 = N \times 50$

$N = \frac{17}{50}$

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

PROBLEM 37 *What will be the resultant pH when 200 mL of an aqueous solution of HCl (pH = 2.0) is mixed with 300 mL of an aqueous solution of NaOH (pH = 12.0)?* **(IIT 1998)**

HCl

200×10^{-2}

2

NaOH

300×10^{-2}

3

$\frac{1}{500} = 2 \times 10^{-3}$

pH = 11.3

SOL

$$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$$

t:0	C	0	0
	C−Cα	Cα	Cα

$$K_a = \frac{C\alpha^2}{1-\alpha} = \frac{\alpha^2}{(1-\alpha)V}$$

SOL

$CH_3COOH + NaOH = CH_3COONa + H_2O$

20 ml / 0.1 M

2 mm

30 ml / 0.2 M

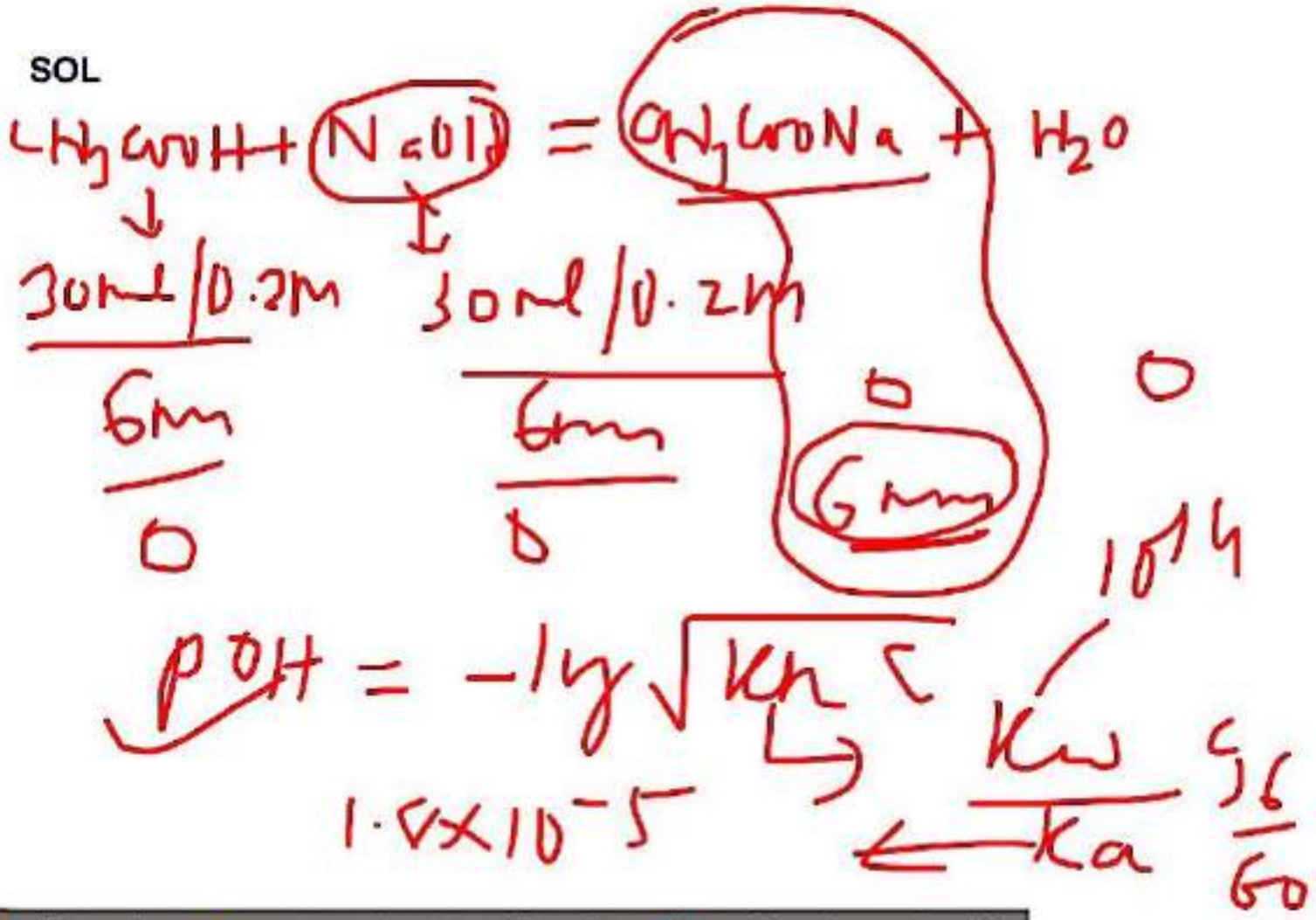
6 mm

4 mm

2 mm

pOH :- $-\log \frac{4}{50}$

SOL



PROBLEM 50 *What volume of 0.1 M sodium formate solution should be added to 50 mL of 0.05 M formic acid to produce a buffer solution of pH = 4.0; pK_a of formic acid = 3.80?* **(Roorkee 1990)**

$$pH = pK_a + \log \frac{S}{A}$$

$$4 \qquad 3.8$$

$$0.3 = \log \frac{S}{A}$$

$$2 = \frac{S}{A}$$

$pH = -\sqrt{K_a C}$

$= \frac{pK_a - \lg C}{2}$

WA

PROBLEM 58 *Calculate the ratio of pH of a solution containing 1 mole of CH_3COONa + 1 mole of HCl per litre and of other solution containing 1 mole CH_3COONa + 1 mole of acetic acid per litre.*

$CH_3COONa + HCl \rightarrow CH_3COOH + NaCl$

1 1 0 0

0 0 1 1

$pH = pK_a + \log \frac{S}{A}$ $\frac{1}{2}$

PROBLEM 66 *A certain weak acid has $K_a = 1.0 \times 10^{-4}$. Calculate the equilibrium constant for its reaction with a strong base.* **(IIT 1991)**

$HA + BOH \rightleftharpoons BA + H_2O$ (Kc)

(HA: W, BOH: S, BA: Basic)

$K_h = \frac{K_w}{K_a} = \frac{10^{-14}}{10^{-4}}$ $K_c = \frac{1}{K_h} = 10^{10}$

10^{10}

$[H^+] = 10^{-3}$. $[H^+] = C\alpha = 10^{-3}$

$\alpha = 10^{-2}$ $\alpha = \frac{10^{-3}}{C(0.1M)}$ ✓

PROBLEM 68 *0.1 M CH_3COOH solution is titrated against 0.05 M NaOH solution. Calculate pH at 1/4th and 3/4th stages of neutralization of acid. The pH for 0.1 M CH_3COOH is 3.*

Case I: $HA + NaOH \rightarrow NaA + H_2O$

0.1 0 0

$0.1 \times \frac{1}{4}$ $0.1 \times \frac{1}{4}$ ✓

$pH = pK_a + \log \frac{0.1/4}{0.3/4}$

$K_a = C\alpha^2$ $0.1 \times (10^{-2})^2$ S

PROBLEM 83 *Calculate pH at which $Mg(OH)_2$ begins to precipitate from a solution containing 0.10 M Mg^{2+} ions. K_{sp} of $Mg(OH)_2 = 1 \times 10^{-11}$.*

(Roorkee 1992)

$IP = K_{sp}$

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

$[OH^-] = 10^{-5}$ $\quad$ 0.1

$pOH = 5$ $\quad$ $pH = 9$

PROBLEM 115 *An acid type indicator, HIn differs in colour from its conjugate base (In^-). The human eye is sensitive to colour differences only when the ratio $[In^-]/[HIn]$ is greater than 10 or smaller than 0.1. What should be the minimum change in the pH of the solution to observe a complete colour change ($K_a = 1.0 \times 10^{-5}$)?* **(IIT 1997)**

$pH = pK_a + \log \frac{[In^-]}{[HIn]}$ — 10 / 0.1

6 / 4 = 1.5 = 2

PROBLEM 115 *An acid type indicator, HIn differs in colour from its conjugate base (In^-). The human eye is sensitive to colour differences only when the ratio $[In^-]/[HIn]$ is greater than 10 or smaller than 0.1. What should be the minimum change in the pH of the solution to observe a complete colour change ($K_a = 1.0 \times 10^{-5}$)?* (IIT 1997)

SOL