Problems on pH & Buffers

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Q1- Calculate the pH of the following :

A) 0.005 M HNO3 ?

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

$[H^+] = 0.005 \longrightarrow PH = -\log[H^+] = -\log[0.005] = \boxed{2.3}$

B) 0.02 H2SO4 ?

$[H^+] = 0.04$

$PH = -\log[H^+] = -\log[0.04] = \boxed{1.4}$

C) 0.1 M HCOOH (ka = 1.8 x 10^-4) ?

weak acid

$Ka = \frac{[H^+][HCOO^-]}{[HCOOH]} = \frac{[H^+]^2}{[HCOOH]} \longrightarrow 1.8 \times 10^{-4} = \frac{[H^+]^2}{0.1}$, $[H^+] = 4.24 \times 10^{-3}$

$\boxed{PH = -\log[H^+] = 2.37}$

Q2- Determine the pH of a solution made by dissolving 0.01 moles of benzoic acid (C_6H_5COOH; pKa = 4.2) in water to form 1 liter of solution. What is the pH?

weak acid , $M = 0.01 mol/L$, $Ka = 10^{-4.2}$, $PH = ??$

$C_6H_5COOH \rightleftharpoons C_6H_5COO^- + H^+$

$Ka = \frac{[H^+]^2}{[C_6H_5COOH]} \rightarrow 10^{-4.2} = \frac{[H^+]^2}{[0.01]} \rightarrow [H^+] = 7.94 \times 10^{-4}$

$\boxed{PH = -\log[H^+] = 3.1}$

Q3- The pKb of a base is 4.5. What is the pH of a 0.01 M solution of the base?

$Kb = 10^{-4.5} \rightarrow Kb = \frac{[OH^-]^2}{[XOH]} \rightarrow 10^{-4.5} = \frac{[OH^-]^2}{0.01} \rightarrow [OH^-] = 5.63 \times 10^{-4}$

$POH = -\log[OH] = 3.25$ $\boxed{PH = 10.75}$

Q4- Calculate the pH of a phosphate buffer that contains 60% monosodium phosphate (NaH_2PO_4) and 40% disodium phosphate (Na_2HPO_4). (pKa = 7.2)

HX X^-

$PH = PKa + \log\frac{[X^-]}{[HX]} \rightarrow PH = 7.2 + \log\frac{[40]}{[60]} = \boxed{7.02}$

Q5- Predict and calculate the pH of a buffer containing 0.05 M acetic acid (CH_3COOH) and 0.1 M sodium acetate (CH_3COONa), when 0.02 M HCl is added to the solution. (K_a for acetic acid = 1.8×10^{-5})

$pKa = -\log Ka$

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

$0.05 + 0.02$ $\quad$ $0.1 - 0.02$

$$PH = Pka + \log \frac{[X^-]}{[HX]} \rightarrow PH = 4.7 + \log \frac{[0.1 - 0.02]}{[0.05 + 0.02]}$$

$$\boxed{PH = 4.75}$$

Q6- Calculate the pH of a solution prepared by dissolving 500 mg of a monoprotic acid (with molecular weight 120 g/mol) in 20 mL of 0.2 M NaOH. The pKa of the acid is 6.8.

mass $\quad$ mw $\quad$ V

$$\underset{-0.2}{HX} \rightleftharpoons \underset{+0.2}{X^-} + H^+ \quad 0.2\ NaOH$$

$$mw = \frac{g}{mol} \rightarrow \frac{g}{mw} = mol \rightarrow \frac{500mg}{120\,g/mol} = 4.16 mmol \rightarrow M = \frac{4.16\cancel{m}mol}{20\,\cancel{m}L} = 0.21\ M$$

$$PH = 6.8 + \log \frac{[0.2]}{[0.21 - 0.2]} = \boxed{8.1}$$

Q7-

a) Calculate the pH of a solution prepared by dissolving 0.03 moles of formic acid (HCOOH; pKa = 3.75) in water to make 1 liter of solution.

$M = 0.03\ mol/L$

$$Ka = \frac{[H^+]^2}{[HX]} \rightarrow 10^{-3.75} = \frac{[H^+]^2}{0.03} \rightarrow [H^+] = 2.3 \times 10^{-3}$$

$$-\log[2.3 \times 10^{-3}] = \boxed{2.64}$$

b) After preparing the solution in part (a), 0.01 moles of concentrated sodium hydroxide (NaOH) were added. What is the new pH of the solution? (Assume no volume change due to the addition of NaOH.)

$$HX \rightleftharpoons X^- + H^+$$

NaOH

$$PH = 3.75 + \log \frac{[2.3 \times 10^{-3} + 0.01]}{[0.03 - 0.01]} = \boxed{3.54}$$

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