Answer on Question #63744 - Chemistry – General Chemistry

Calculate the pH change when 10. mL of 3.0 M HCl are added to 500. mL of the following A) pure water B) aqueous solution of 3.0g of formic acid C) aqueous solution of 4.0g potassium formate D) aqueous solution containing 3.0 g of formic acid and 4.0 g of potassium formate.

Solution.

a) $pH(H_2O) = 7$
$n(HCl) = 3.0\ M \times 0.01\ L = 0.03\ mol$
$C_2(HCl) = 0.03\ mol / (0.5+0.01) = 0.0588\ mol/L$
$pH = -\lg C(HCl) = -\lg 0.0588 = 1.22$
pure water: pH = 7; final pH = 1.22; change = 5.78

b) $n(HCOOH) = m(HCOOH)/M(HCOOH) = 3/46 = 0.0652\ mol$
$C(HCOOH) = n(HCOOH)/0.5\ L = 0.0652/0.5 = 0.13\ M$
$K_{a,\ HCOOH} = 1.8 \cdot 10^{-4}$; $pK_a = -\lg K_{a,\ HCOOH} = 3.75$

$$pH = \frac{1}{2} pK_a - \frac{1}{2}\lg C_{HCOOH} = 1/2 \times 3.75 - 1/2 \times \lg(0.13) = 2.32$$

HCl – strong acid; pH = 1.22
formic acid : pH = 2.32; final pH = 1.22; change = 1.1

c) $HCOOK \rightarrow K^+ + HCOO^-$
$HCOO^- + H_2O \rightarrow HCOOH + OH^-$
$C(HCOOK) = 4/(84 \times 0.5) = 0.095\ M$
$K_{a,\ HCOOH} = 1.8 \cdot 10^{-4}$; $pK_a = 3.75$

$$pH = 7 + \frac{1}{2} pK_{a,HCOOH} + \frac{1}{2}\lg C_{HCOOK}$$

$pH = 7 + 1/2 \times 3.75 + 1/2 \times \lg(0.095) = 8.36$
$HCOOK + HCl \rightarrow HCOOH + KCl$
$C(HCOOH) = 0.0588\ mol/L$
$C(HCOOK) = 0.095 - 0.0588 = 0.0362$

$$pH = pK_{a,HCOOH} - \lg \frac{C_{HCOOH}}{C_{HCOOK}}$$

$pH = 3.75 - \lg (0.0588/0.0362) = 3.54$
potassium formate : pH = 8.36; final pH = 3.54; change = 4.82

d) $$pH = pK_{a,HCOOH} - \lg \frac{C_{HCOOH}}{C_{HCOOK}}$$

$pH = 3.75 - \lg (0.13/0.095) = 3.61$
$C(acid) = 0.13 + 0.0588 = 0.1888\ M$
$C(salt) = 0.095 - 0.0588 = 0.0362\ M$
$pH = 3.75 - \lg (0.1888/0.0362) = 3.03$
buffer: pH = 3.61; final pH = 3.03; change = 0.58

Answer: a) pure water: pH = 7; final pH = 1.22; change = 5.78
b) formic acid : pH = 2.32; final pH = 1.22; change = 1.1
c) potassium formate : pH = 8.36; final pH = 3.54; change = 4.82
d) buffer: pH = 3.61; final pH = 3.03; change = 0.58