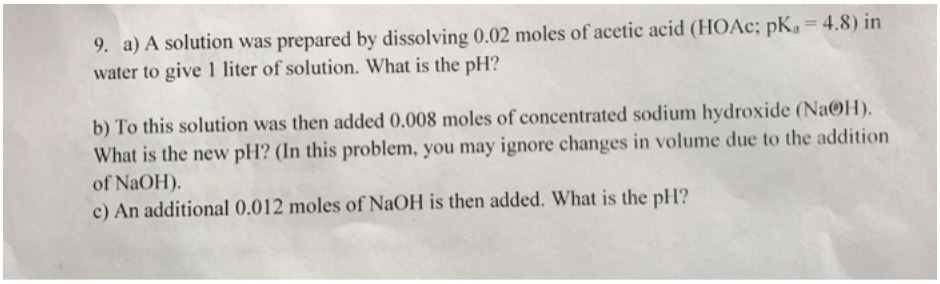
Question: A solution was prepared by dissolving 0.02 moles of acetic aci...



9. a) A solution was prepared by dissolving 0.02 moles of acetic acid (HOAc; $pK_a = 4.8$) in water to give 1 liter of solution. What is the pH?

b) To this solution was then added 0.008 moles of concentrated sodium hydroxide (NaOH). What is the new pH? (In this problem, you may ignore changes in volume due to the addition of NaOH).

c) An additional 0.012 moles of NaOH is then added. What is the pH?

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Expert Answer

Anonymous answered this
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Then, the concentration of CH_3COOH solution $= \frac{0.02\ mol}{1\ L}$

$= 0.02\ M$

pKa of $CH_3COOH = 4.8$

CH_3COOH is a weak acid.

For weak acid, $pH = \frac{1}{2} pKa + \frac{1}{2} \log c$

$\Rightarrow pH = \frac{1}{2} \times 4.8 + \frac{1}{2} \times \log (0.02)$

$\Rightarrow pH = \frac{1}{2} \times 4.8 + \frac{1}{2} \times (-1.70)$

$\Rightarrow pH = 2.4 - 0.85$

$\Rightarrow pH = 1.55$

Therefore, the pH value is 1.55

(b) Number of mole of NaOH $= 0.008\ mol$

Number of mole of $CH_3COOH = 0.02\ mol$

$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$

So, 0.008 mol of NaOH reacts with 0.008 mol of CH_3COOH and produces 0.008 mol of CH_3COONa

Then, number of mole of CH_3COOH excess $= 0.02\ mol - 0.008\ mol$

$= 0.012\ mol$

Total volume of the solution = 1 L

Then, the mixture of the solution contains,

$[CH_3COONa] = \frac{0.008\ mol}{1\ L}$

$= 0.008\ M$

and $[CH_3COOH] = \frac{0.012\ mol}{1\ L}$

$= 0.012 M$

Again, pKa of $CH_3COOH = 4.8$

The mixture of the solution is a buffer solution of weak acid, CH_3COOH and its salt, CH_3COONa

For buffer solution, $pH = pKa + \log \frac{[salt]}{[acid]}$

$\Rightarrow pH = pKa + \log \frac{[CH_3COONa]}{[CH_3COOH]}$

$\Rightarrow pH = 4.8 + \log \left(\frac{0.008\ M}{0.012\ M} \right)$

$\Rightarrow pH = 4.8 + \log (0.67)$

$\Rightarrow pH = 4.8 - 0.174$

$\Rightarrow pH = 4.626$

Therefore, the new pH is 4.626

(c) Given, an additional 0.012 mol of NaOH is added.

Then, total number of mole of NaOH $= 0.012\ mol + 0.008\ mol$

$= 0.02\ mol$

Number of mole of $CH_3COOH = 0.02\ mol$

$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$

So, 0.02 mol of CH_3COOH reacts with 0.02 mol of NaOH and produces 0.02 mol of salt, CH_3COONa

Total volume of the solution = 1 L

Then, $[CH_3COONa]$ in the mixture of the solution

$= \frac{0.02\ mol}{1\ L}$

$= 0.02\ M$

pKa of $CH_3COOH = 4.8$

CH_3COONa is a salt of weak acid, CH_3COOH and strong base, NaOH

$$\Rightarrow pH = \frac{1}{2} \times 14 + \frac{1}{2} \times 4.8 + \frac{1}{2} \times \log(0.02)$$

$$\Rightarrow pH = \frac{1}{2} \times 14 + \frac{1}{2} \times 4.8 + \frac{1}{2} \times (-1.70)$$

$$\Rightarrow pH = 7 + 2.4 - 0.85$$

$$\Rightarrow pH = 9.4 - 0.85$$

$$\Rightarrow pH = 8.55$$

Therefore, the pH is 8.55

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