Kantipur Engineering College

Dhapakhel, Lalitpur

***Solution***

**Tutorial II, Engineering Chemistry, Buffer**

1. Calculate the pH of the buffer that is 0.3M in CH3NH2 and 0.146M in CH3NH3Cl. Kb for CH3NH2 is 3.6 x10-4.

**Solution:**

Molar concentration of weak base = [Base] = 0.3 M

Molar concentration of salt = [Salt] = 0.146 M

Now, pOH = pKb + log = -log 3.6 x10-4 + log = 3.13

Therefore, pH = 14 - pOH = **10.8 Answer**

1. A buffer is made by mixing 400 ml of 0.3 M acetic acid with 200 mL of 0.6M sodium acetate. Calculate the pH of the resulting buffer. pKa= 4.74.

**Solution:**

Molar concentration of acetic acid after mixing [Acid] = = = 0.2 M

Molar concentration of sodium acetate after mixing [Salt] = = = 0.2 M

Now, pH = pKa + log = 4.74+ log = **4.74 Answer**

1. If 3.0 millimole (3.0 x 10-3 mol) of NaOH is added to 100 ml of a buffer which is 0.10 M in acetic acid and 0.1 M in sodium acetate. What will be the change in pH of the solution after the addition of NaOH? pKa = 4.74.

**Solution:**

pH of buffer before adding NaOH; pH = pKa + log = 4.74+ log = 4.74

Molarity of added NaOH = = = 0.03 M

CH3COOH + NaOH = CH3COONa + H2O; when sodium hydroxide is added to buffer having acetic acid, the concentration of acetic acid decreases and the concentration of sodium acetate increases.

Now, new concentration of acetic acid after adding sodium hydroxide = 0.1 - 0.03 = 0.07 M

and, new concentration of sodium acetate after adding sodium hydroxide = 0.1 + 0.03 = 0.13 M

Therefore, pH of the buffer after adding sodium hydroxide;

pH = pKa + log = 4.74+ log = 5.0

Therefore, change in pH of the buffer after adding sodium hydroxide = 5.0 - 4.74 = **0.26 Answer.**

1. Calculate the concentration of bromoacetic acid and sodium bromoacetate in the solution whose pH is 3.0, and in which the total concentration is 0.20mol/litre. Ka for the bromoacetic acid= 2.0 x 10-3.

**Solution:**

Let the concentration of bromoacetic acid = x and concentration of sodium bromoacetate = 0.2 - x

pH = -log2.0 x 10-3 + log = 2.70+ log

or, 3 = 2.70+ log or, antilog 0.3 = or, 1.99 = or, 2.99x = 0.2 or, x = 0.066 M

Therefore the concentration of bromoacetic acid = **0.066 M** and concentration of sodium bromoacetate = 0.2 - 0.066 = **0.13 M Answer**

1. To a 100 mL of buffer solution containing 0.1M NH4OH and 0.1 M NH4Cl, if 10 mL of 0.1M HCl is added. What will be the pH of the resulting solution? pKb = 4.74.

Molar concentration of NH4OH =[Base] = = = 0.09 M

Molar concentration of NH4Cl= [Salt] = = = 0.09 M

Molar concentration of HCl = = = 0.009 M

We know that NH4OH + HCl = NH4Cl + H2O

Therefore the concentration of NH4OH decreases and concentration of NH4Cl increases.

New concentration of NH4OH= [Base] = 0.09-0.009 = 0.081 M

New concentration of NH4Cl = [Salt] = 0.09+0.009 = 0.099M

Now, pOH = pKb + log = 4.74+ log = 4.83

Therefore pH = 14 - POH = **9.17 Answer**

1. How much of sodium acetate is to be added in a liter of 1M acetic acid solution to make its pH 5.7? Ka for acetic acid is 1.8x10-5.

**Solution:**

We Know, pH = pKa + log or, 5.7 = -log1.8 x 10-5 + log or, 5.7 = 4.74 + log

Therefore, [Salt] = 9.12 M

Since, Molarity = or, 9.12 =

Therefore, Weight in grams of sodium acetate to be added is **747.89 grams. Answer**

1. To 100 mL of 0.2 M NH4OH is added 0.2 g of NH4Cl. Find the pH of the resulting solution? pKb = 4.74.

**Solution:** Molarity of NH4Cl = [Salt] = = = 0.037 M

pOH = pKb + log = 4.74+ log = 4.0

Therefore, pH = **10 Answer**

1. To 1 liter of buffer consisting of 0.1 M ammonia and 0.2 M ammonium chloride is added (i) 0.2 g of NaOH and (ii) 1mL of 0.5 M HCl. Find the change of pH of buffer in each case. pKb = 4.74.

**Solution**: **a) pH of buffer before adding NaOH or HCl**

pOH = pKb + log = 4.74+ log = 5.04, Therefore pH = 8.96

**b) pH of buffer after adding NaOH**

Molarity of NaOH = 0.005 M

ammonia.PNG

According to the Le-chatelier principal due to common ion effect the concentration of OH- ions increases due to the addition of NaOH which shifts the equilibrium in backward direction increasing the concentration of NH4OH by consuming NH4+ ions from the buffer. This in turn will decrease the concentration of NH4Cl.

New concentration of NH4OH = [Base] = 0.1 + 0.005 = 0.105 M

New concentration of NH4Cl = [Salt] = 0.2 - 0.005 = 0.195 M

Now, pOH = pKb + log = 4.74+ log = 5.00, Therefore pH = 9.00

Change in pH = 9.00 - 8.96 = **0.04 Answer**

**c) pH of buffer after adding HCl**

Since the volume of HCl added is 1 mL we ignore the change in volume.

The molarity of HCl in the buffer = = = 0.0005 M

New concentration of NH4OH = [Base] = 0.1 - 0.0005 = 0.0995 M

New concentration of NH4Cl = [Salt] = 0.2 + 0.0005 = 0.2005 M

Therefore, pOH = pKb + log = 4.74+ log = 5.04, Therefore pH = 8.96

Change in pH = 8.96 - 8.96 = **0.00 Answer**

1. To 1 liter of 0.1 M CH3COOH is added 0.2 g of NaOH. Find the pH of the resulting solution. Ka for acetic acid is 1.8 x 10-5.

**Solution:** Molarity of NaOH = = = 0.005 M

New concentration of acetic acid = [Acid] = 0.1 - 0.005 = 0.095 M

Concentration of sodium acetate = [Salt] = 0.005 M

Now, pH = pKa + log = 4.74 + log = **3.46 Answer**

1. Calculate the pH of a solution when 50 ml of 0.05 M HCl is added to 100 ml of 0.1 M NH3 solution. (Kb= 1.75x10-5 )

**Solution:**

Molarity of HCl in the solution = = = 0.0166 M

Molarity of NH3 in the solution = = = 0.066 M

We know that HCl + NH3 = NH4Cl; so salt is formed in the solution and concentration of NH3 gets decreased

New concentration of ammonia= [Base] = (0.066 - 0.0166) M

Concentration of salt = [Salt] = 0.0166 M

Therefore, pOH = pKb + log = -log 1.75 x 10-5 + log = 3.44

pH = 14 - pOH = **10.5 Answer**

1. To prepare a liter of a buffer solution of pH 10, how many grams of NH4Cl has to be added to a liter of 0.25 M NH4OH solution? Also calculate the degree of ionization of NH4OH (pKb = 4.74)

**Solution:** Molecular Weight of NH4Cl = 53.5 and let the weight in gram of NH4Cl = x

Therefore the concentration of NH4Cl = =

Now, pOH = pKb + log =

or 4 = 4.74+ log or, x= **2.43 g Answer**