**Chapter 17 exercises**

**Q1**. Practice exercise page 721

Calculate the pH of a solution containing 0.085 M nitrous acid HNO2 ; Ka = 4.5 x 10-4 ) and 0.10 M

potassium nitrite NaNO2 .

Answer:

HNO2  is a weak acid

NaNO2  is a salt of strong electrolyte

HNO2 ↔ H+  + NO2-

NaNO2  → Na+  + NO2-

HNO2 ↔ H+  + NO2-

initial 0.085 M 0 M 0 M

change - X M + X M + X M

equilibrium ( 0.085 – X) M X M (0.10 + X) M

Ka = 4.5 x 10-4  = [H+ ] [NO2- ] / [HNO2] = (X) (0.1 + X) / (0.085 – X)

4.5 x 10-4  = 0.10 X / 0.085

X = 3.825 x 10-4  [H+ ] pH = - log [H+ ] = - log (3.825 x 10-4 )

pH = 3.42

**Q2.** Practice exercise page722

Calculate the formate ion concentration and pH of a solution that is 0.050 M in formic acid

(CHOOH) ( Ka = 1.8 x 10-4 ) and 0.10 M HNO3 .

Answer:

HCOOH (aq)  ↔ HCOO-  (aq)  + H+ (aq)

HNO3 (aq)  → H+  + NO3 –

HCOOH (aq)  ↔ HCOO-  (aq)  + H+ (aq)

initial 0.050 M 0 M 0.10 M

change - X M + X M + X M

equilibrium (0.050 – X) X M (0.10 + X)

Ka = 1.8 x 10-4  = [HCOO- ] [H+ ] / [HCOOH] = (0.10 + X) (X) / (0.050 – X)

X = 0.9 x 10-4 M [H+ ]

Concentration of [H+ ] after equilibrium = 0.10 + X = 0.10 + 0.9 x 10-4  = 0.10 M

pH = - log (0.10) = 1.00

**Q3**. Practice exercise page 725

Calculate the pH of a buffer composed of 0.12 M benzoic acid and 0.20 M sodium benzoate.

(Ka = 6.3 x 10-5 )

Answer:

pH = pKa + log (base) / (acid)

pKa = - log (6.3 x 10-/5 ) = 4.2

pH = 4.20 + log (0.2 / 0.12) = 4.20 + 0.22 = 4.42

**Q4**. Practice exercise page 728

Determine:

a) The pH of the original buffer described in exercise 17.5 after the addition of 0.020 M HCl and

b) The pH of solution that would result from the addition of 0.020 M HCl to 1.00 L of pure water.

Answer:

a) CH3COOH ↔ CH3COO-  + H+

initial 0.30 M 0.30 M 0 M

change - 0 M 0.02 M

equilibrium (0.30 + 0.02) M (0.30 – 0.02) M 0 M

pH = Ka + log (0.28 / 0.32) = 4.68

b) pH = - log (0.020) = 1.70

The small amount of HCl added change the pH to more acidic (1.70) of pure water, while

the pH change of the buffer is very little.

**Exercises page 759**

**17.15**

Use the information in Appendex D to calculate the pH of:

1. a solution that is 0.060 M in potassium propionate (C2H5COOK) and 0.085 M in propionic

acid (C2H5COOH).

b) a solution that is 0.075 M in tri methyl amine, (CH3)­3 N, and 0.10 M in tri methyl ammonium

Chloride (CH3)3 NHCl .

1. a solution that is made of by mixing 50.0 mL of 0.15 M acetic acid and 50 mL of 0.20 M sodium

acetate.

Answer:

a) C2H5COOH ↔ H+  + C2H5COO-  Weak acid (weak electrolyte)

C2H5COOK ↔ K+  + C2H5COO-  Strong electrolyte salt

C2H5COOH ↔ H+  + C2H5COO-

initial 0.085 M 0 M 0 M

change - X M + X M + X M

equilibrium ( 0.085 – X)M X M (0.06 + X)M

Ka = 1.3 x 10-5 = (X) (0.06 + X) / (0.085 – X) = 0.06 X / 0.085

X = 1.842 x 10-5 M = [H+ ]

pH = - log ( 1.842 x 10-5 ) = 4.73

b) (CH3)3 N + H2O ↔ (CH3)3 NH+  + OH-

(CH3)3 NHCl → (CH3)3 NH+  + Cl-

(CH3)3 N + H2O ↔ (CH3)3 NH+  + OH-

initial 0.075 M 0.10 M 0 M

change - X M + X M + X M

equilibrium (0.075 – X) M (0.10 + X) M X M

Ka = 6.4 x 10-5  = (X) (0.10 + X) / (0.075 – X) = 0.10 X / 0.075

X = 4.8 x 10-5 M = [OH- ]

[OH- ] [H+ ] = 1.0 x 10-14  [H+ ] = 1.0 x 10-14 / 4.8 x 10-5  = 0.21 x 10-9 M

pH = - log ( 0.21 x 10-9 ) = 9.68

c) volume of solution = 50 mL + 50 mL = 100 mL

mole of acetic acid = (0.15 M x 50 mL) / (100 mL) = 0.075 M CH3COOH

mole of sodium acetate = (0.2 M x 50 mL) / (1009 mL) = 0.10 M CH3COONa

CH3COOH ↔ CH3COO- + H+

Initial 0.075 M 0.10 M 0 M

Change - X M + X M + X M

Equilibrium (0.075 – X) M (0.10 + X) M X M

Ka = 1.8 x 10-4 = (X) (0.10 + X) / (0.075 – X) = 0.10 X / 0.075

X = 1.35 x 10-4 M = [H+ ] = 1.4 x 10-4 M

**17.17**

a) Calculate the percent ionization of 0.0075 M butanoic acid (Ka = 1.5 x 10-5 ).

b) Calculate the percent ionization of 0.0075 M butanoic acid in a solution containing 0.085 M

sodium butanoiate.

Answer:

a) C3H7COOH butanoic acid is a weak acid

C3H7COONa is a strong electrolyte salt

C3H7COOH ↔ C3H7COO-  + H+

initial 0.0075 M 0 M 0 M

change - X M + X M + X M

equilibrium (0.0075 – X) M X M X M

Ka = 1.5 x 10-5  = X2  / (0.0075 – X) = X2  / 0.0075

X = 3.35 x 10-4 M =[H+ ]

Percent ionization = H+ equilibrium  / [HA] initial x 100 = (3.35 x 10-4 )/ (0.0075) x 100 = 4.5%

b) C3H7COOH ↔ H+  + C3H7COO-

initial 0.0075 M 0 M 0.085 M

change - X M + X M + X M

equilibrium (0.0075 – X) M X M (0.085 + X) M

Ka = 1.5 10-5 = (X) (0.085 + X) / (0.0075 – X) = 0.085 X / 0.0075

X = 0.132 x 10-/5 M = [H+ ]

Percent ionization = (0.132 x 10-5 ) x 100 / (0.0075) = 0.018%

**17.21**

a) Calculate the pH of a buffer that is 0.12 M in lactic acid and 0.11 M in sodium acetate.

b) Calculate the pH of a buffer formed by mixing 85 mL of 0.13 M lactic acid with 95 mL of 0.15 M

sodium acetate (Ka = 1.4 x 10-4)

Answer:

a) pH = pKa + log ( base / acid)

pKa = - log Ka = - log (1.4 x 10-4) = 3.85

pH = 3.85 + log (0.11 / 0.12) = 3.85 + (-0.04) = 3.81

b) volume of solution = 85 mL + 95 mL = 180 mL

concentration of lactic acid = (0.13 M x 85 mL) / (180 mL) = 0.061 M

concentration of sodium lactate = (0.15 M x 95 mL) / (180 mL) = 0.079 M

pH = 3.85 + log (0.079 / 0.061) = 3.96

**17.25**

How many moles of sodium hypobromate (NaBrO) should be added to 1.0 L of 0.050 M

hypobromous acid (HBrO)to form a buffer solution of pH = 9.15? assume that no volume

change occur when NaBrOis added. (Ka = 2.5 x 10-9)

Answer:

pKa = - log Ka = - log (2.5 x 10-9) = 8.60

pH = pKa log (base / acid)

9.15 – 8.60 = log ( base / 0.050)

Base = [NaBrO] = 3.55 x 0.05 = 0.177 M

mole of NaBrO = 1.0 L x 0177 mol/L = 0.18 mole

**17.27**

A buffer solution contains 0.10 mole of CH3COOH and 0.13 mole of CH3COONa in 1.0 L.

a) what is the pH of this solution?

b) What is the pH of the buffer after addition of 0.02 mole KOH?

c) What is the pH of the buffer after addition of 0.02 mole of HNO3 ?

Answer:

a) pH = pKa + log (base/acid) = 4.74 + log (0.13 mol/L )/(0.10 mol/L)

pH = 4.74 + 0.114 = 4.64

b) CH3COOH + OH-  → H2O + CH3COO-

buffer before addition 0.10 M 0 M 0.13 M

addition - 0.02 -

buffer after addition (0.10 – 0.02) M 0 M (0.13 + 0.02) M

pH = pKa + log (base / acid0 = 4.74 + log (0.15 / 0.08) = 5.01

c) CH3COOH ↔ H+  + CH3COO-

buffer before addition 0.10 M 0 M 0.13 M

addition 0.020 M 0.02 0 M

buffer after addition (0.10 + 0.02) M 0 M (0.13 - 0.02) M

pH = pKa + log (base / acid0 = 4.74 + log (0.11 / 0.12) = 4.70