IONIC EQUILIBRIUM-II

Exercise-1

Note : *Take water as solvent and temperature as 25ºC, if not specified.*
Take log 2 = 0.3, log 3 = 0.48, log 5 = 0.7, log 7 = 0.845, if not specified.

Marked questions are recommended for Revision.

PART - I : SUBJECTIVE QUESTIONS

Section (A) : Buffer Solutions : Definition and Identification

Commit to memory :

Buffer Solutions : Solution containing weak acid and it's conjugate base, solution containing weak base and it's conjugate acid, solution containing salt of weak acid and weak base.

Preparation :

(i) Solution of weak acid (or weak base) + Solution of it's conjugate base (or it's conjugate acid)

(ii) Solution of weak acid (or weak base) + Solution of strong base (or strong acid) ($n_1 > n_2$)

(iii) Solution of salt of weak acid and strong base (or salt of weak base and strong acid) + Solution of strong acid (or strong base) ($n_1 > n_2$)

A-1. V_1 mL of a CH_3COONa solution (of molarity M_1) and V_2 mL of a HCl solution (of molarity M_2) are available. Can the two be mixed to obtain a buffer solution ? If yes, what should be the mathematical condition relating M_1, M_2, V_1 & V_2 for this ?

A-2. Select pair(s) of solutions from below which could be mixed to produce a buffer solution :
NH_4OH solution (S_1), $(NH_4)_2SO_4$ solution (S_2), HCl solution (S_3), KOH solution (S_4).

Section (B) : pH Calculation : Buffer solutions generated from Monobasic acid / Monoacidic base

Commit to memory :

pH Calculation : Buffer solutions generated from Monobasic acid / Monoacidic base :

(i) pH of a buffer solution consisting of a weak acid (HA ; C_1 concentration) and its salt with a strong base (NaA ; C_2 concentration of anion) : $pH = pK_a + \log \frac{[\text{Anion of Salt}]}{[\text{Acid}]}$

(ii) pH of a buffer solution consisting of a weak base (B ; C_1 concentration) and its salt with a strong acid (BH^+Cl^- ; C_2 concentration of cation) : $pOH = pK_b + \log \frac{[\text{Cation of Salt}]}{[\text{Base}]}$

B-1. Calculate pH of following solutions :
(a) (4 g CH_3COOH + 4.1 g CH_3COONa) in 100 mL aqueous solution ; K_a for $CH_3COOH = 1.8 \times 10^{-5}$
(b) 5 mL of 0.1 M BOH + 25 mL of 0.1 M BCl ; K_b for $BOH = 1.8 \times 10^{-5}$

B-2. 50 mL of 0.2 M solution of an acid HA ($K_a = 10^{-5}$) & 50 mL of a NaA solution are given. What should be the concentration of NaA solution to make a buffer solution with pH = 4 upon mixing the two ?

B-3. Calculate the pH of 0.5 L of a 0.2 M NH_4Cl – 0.2 M NH_3 buffer before and after addition of (a) 0.05 mole of NaOH and (b) 0.05 mole of HCl. Assume that the volume remains constant.
[Given : pK_b of $NH_3 = 4.74$]

PART - II : ONLY ONE OPTION CORRECT TYPE

Section (A) : Buffer Solutions : Definition and Identification

Commit to memory :

Buffer Solutions : Solution containing weak acid and it's conjugate base, solution containing weak base and it's conjugate acid, solution containing salt of weak acid and weak base.

Preparation :

(i) Solution of weak acid (or weak base) + Solution of it's conjugate base (or it's conjugate acid)

(ii) Solution of weak acid (or weak base) + Solution of strong base (or strong acid) ($n_1 > n_2$)

(iii) Solution of salt of weak acid and strong base (or salt of weak base and strong acid) + Solution of strong acid (or strong base) ($n_1 > n_2$)

A-1. A solution is 0.1 M in CH_3COOH and 0.1 M in CH_3COONa. Which of the following will change its pH significantly?

(A) Addition of small amount of water (B) Addition of small amount of HCl

(C) Addition of small amount of NaOH (D) None will change the pH significantly.

A-2. Which of the following may be added to one litre of water to act a buffer ?

(A) One mole of CH_3COOH and one mole of HCl

(B) One mole of NH_4OH and one mole of NaOH

(C) One mole of NH_4Cl and one mole of HCl

(D) One mole of CH_3COOH and 0.5 mole of NaOH

A-3. In which of the following respective volume ratios should 0.1 M NH_4OH solution & 0.1 M HCl solution be mixed, so that the resulting solution behaves like a buffer solution ?

(A) 1 : 1 (B) 2 : 1

(C) 1 : 2 (D) No such volume ratio is possible

Section (B) : pH Calculation : Buffer solutions generated from Monobasic acid / Monoacidic base

Commit to memory :

pH Calculation : Buffer solutions generated from Monobasic acid / Monoacidic base :

(i) pH of a buffer solution consisting of a weak acid (HA ; C_1 concentration) and its salt with a strong base (NaA ; C_2 concentration of anion) : $pH = pK_a + \log \frac{[\text{Anion of Salt}]}{[\text{Acid}]}$

(ii) pH of a buffer solution consisting of a weak base (B ; C_1 concentration) and its salt with a strong acid (BH^+Cl^- ; C_2 concentration of cation) : $pOH = pK_b + \log \frac{[\text{Cation of Salt}]}{[\text{Base}]}$

B-1. Fear or excitement generally cause one to breathe rapidly and it results in the decrease of concentration of CO_2 in blood. In what way, it will change pH of blood ?

(A) pH will significantly increase (B) pH will significantly decrease

(C) No significant change in pH (D) pH will be 7

B-2. pH of a mixture containing 0.1 M X^- and 0.2 M HX is : [pK_b (X^-) = 4]

(A) 4 + log 2 (B) 4 – log 2 (C) 10 + log 2 (D) 10 – log 2

B-3. K_a for HCN is 5×10^{-10}. For maintaining a constant pH of 9, the volume of 5 M KCN solution required to be added to 10 mL of 2 M HCN solution is :

(A) 4 mL (B) 8 mL (C) 2 mL (D) 10 mL

B-4. A buffer solution made up of BOH and BCl of total molarity 0.29 M has pH = 9.6 and $K_b = 1.8 \times 10^{-5}$. Concentration of salt and base respectively is :

(A) 0.09 M and 0.2 M (B) 0.2 M and 0.09 M

(C) 0.1 M and 0.19 M (D) 0.19 M and 0.1 M

PART - III : MATCH THE COLUMN

1. At the equivalence point of titration of (equivalence point = the point at which reaction is just complete) :

(A) a strong acid with a strong base	(p) pH < 7
(B) a weak acid with a strong base	(q) pH > 7
(C) a weak base with a strong acid	(r) pH = 7
(D) a weak acid with a weak base	(s) pH may be less than or greater than 7

Exercise-2

Marked questions are recommended for Revision.

PART - I : ONLY ONE OPTION CORRECT TYPE

1. To prepare a buffer of pH 8.26 amount of $(NH_4)_2 SO_4$ to be added to 500 mL of 0.01 M NH_4OH solution is : $[pK_a (NH_4^+) = 9.26]$

(A) 0.05 mole (B) 0.025 mole
(C) 0.10 mole (D) 0.005 mole

2. A weak acid (HA) after treatment with 12 mL of 0.1 M strong base (BOH) solution has a pH of 5. At the end point, the volume of same base solution required is 27 mL. K_a of acid is :

(A) 1.8×10^{-5} (B) 8×10^{-6} (C) 1.8×10^{-6} (D) 8×10^{-5}

PART - II : SINGLE AND DOUBLE VALUE INTEGER TYPE

1. How many of the following statement(s) is/are correct for making a buffer solution ?

(i) It can be formed by mixing equal concentrations of HCl and CH_3COONa
(ii) It can be formed by mixing equal concentrations of HNO_3 and NH_3
(iii) It can be formed by mixing equal concentrations of HCOOH and Aniline.
(iv) It can be formed by mixing equal volumes of NH_4OH and $HClO_4$.
(v) It can be formed by mixing equal volumes of HCN and KOH.
(vi) There is no change in the pH of a buffer solution on adding small amount of a strong acid/base.
(vii) The concentrations of acid and base being mixed must be different to form a buffer.
(viii) The volumes of acid and base being mixed must be different to form a buffer.
(ix) The concentrations and volumes of acid and base being mixed must be different to form a buffer.

2. 1 M benzoic acid ($pK_a = 4.2$) and 1M C_6H_5 COONa solutions are given separately. What is the volume of benzoic acid required to prepare a 93 mL buffer solution of pH = 4.5 ?

PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1. A buffer solution can be prepared from a mixture of : **[JEE-1999, 3/80]**

(A) Sodium acetate and acetic acid in water
(B) Sodium acetate and hydrochloric acid in water
(C) Ammonia and ammonium chloride in water
(D) Ammonia and sodium hydroxide in water

Exercise-3

JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

JEE(MAIN) OFFLINE PROBLEMS

1. The pK_a of a weak acid (HA) is 4.5. The pOH of an aqueous buffered solution of HA, in which 50% of the acid is ionized, is : **[AIEEE-2007, 3/120]**

(1) 9.5 (2) 7.0 (3) 4.5 (4) 2.5

JEE(MAIN) ONLINE PROBLEMS

1. In some solutions, the concentration of H_3O^+ remains constant even when small amounts of strong acid or strong base are added to them. These solutions are known as :

[JEE(Main) 2014 Online (11-04-14), 4/120]

(1) Ideal solutions (2) Colloideal solutins (3) true solutions (4) Buffer solutions

2. Addition of sodium hydroxide solution to a weak acid (HA) results in a buffer of pH 6. If ionisation constant of HA is 10^{-5}, the ratio of salt to acid concentration in the buffer solution will be :

[JEE(Main) 2017 Online (08-04-17), 4/120]

(1) 10 : 1 (2) 4 : 5 (3) 1 : 10 (4) 5 : 4

3. 50 mL of 0.2 M ammonia solution is treated with 25 mL of 0.2 M HCl . If pK_b of ammonia solution is 4.75, the pH of the mixture will be : **[JEE(Main) 2017 Online (09-04-17), 4/120]**

(1) 4.75 (2) 3.75 (3) 9.25 (4) 8.25

4. 20 mL of 0.1 M H_2SO_4 solution is added to 30 mL of 0.2 M NH_4OH solution. The pH of the resultant mixture is : (pK_b of NH_4OH = 4.7) **[JEE(Main) 2019 Online (09-01-19), 4/120]**

(1) 9.0 (2) 5.2 (3) 9.4 (4) 5.0

Answers

EXERCISE – 1

PART – I

A-1. Yes, $M_1 V_1 > M_2 V_2$. **A-2.** S_1 & S_2 ; S_1 & S_3 ; S_2 & S_4.

B-1. (a) 4.62 (b) 8.56 **B-2.** 0.02 M **B-3.** pH = 9.26 ; (a) pH = 9.74 ; (b) 8.78

PART - II

A-1. (D) **A-2.** (D) **A-3.** (B) **B-1.** (C) **B-2.** (D)

B-3. (C) **B-4.** (A)

PART - III

1. (A) → R; (B) → Q; (C) → P; (D) → S

EXERCISE – 2

PART - I

1. (B) **2.** (B)

PART - II

1. 5 [(i) to (v)] **2.** 31

PART - III

1. (A) (B)(C)

EXERCISE – 3

JEE(MAIN) OFFLINE PROBLEMS

1. (1)

JEE(MAIN) ONLINE PROBLEMS

1. (4) **2.** (1) **3.** (3) **4.** (1)