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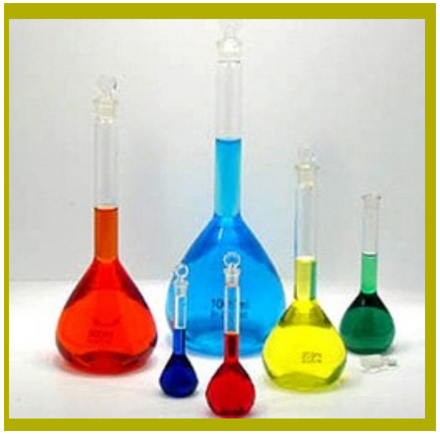
BCH 312

Experiment (5)

Preparation of Buffer Solutions by Different Ways



Objectives

1) To learn how to prepare a buffer by different ways.

Introduction

For example: prepare **0.1 liters** of **0.045 M** sodium phosphate buffer, **pH 7.5** solution

Dissociation of phosphoric acid

$$H_3PO_4 \rightleftharpoons H^+ + H_2PO_4^- \qquad pK_1 = 2.12$$

$$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{-2} \qquad pK_2 = 7.21$$

$$HPO_4^{-2} \rightleftharpoons H^+ + PO_4^{-3} \qquad pK_3 = 12.30$$

- The pH of this buffer is a little above the pka_2 of H_3PO_4 , consequently , the two major ionic species present are $H_2Po_4^-$ (conjugate acid) and HPO_4^{-2} (conjugate base) with the HPO_4^{-2} predominating { since the pH of the buffer is slightly basic }

+ The buffer can be prepared in any one of several ways :

1. By mixing NaH_2PO_4 **(conjugate acid)** and Na_2HPO_4 **(conjugate base)** in the proper proportions ,

2. By starting with H_3PO_4 and converting it to NaH_2PO_4 plus Na_2HPO_4 by adding the proper amount of NaOH ,

3. By starting with NaH_2PO_4 and converting a portion of it to Na_2HPO_4 by adding NaOH ,

4. By starting with Na_2HPO_4 and converting a portion of it to NaH_2PO_4 by adding a strong acid such as HCL ,

5. By starting with Na_3PO_4 and converting it to NaH_2PO_4 plus Na_2HPO_4 by adding HCL ,and

6. By mixing Na_3PO_4 and NaH_2PO_4 in the proper proportions .

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- **Regardless of which method is used , the first step involves calculating the proportion and amounts of the two ionic species in the buffer .**

- Total no. of moles of phosphate buffer= M x V= 0.1 ×0.045 = 0.0045 moles

- $PH = PKa_2 + \log [HPO_4^{-2}] / [H_2PO_4^-]$
- Assume $[A^-] = y$, $[HA] = 0.045 - y$
- $7.5 = 7.2 + \log (y / 0.045-y)$
- $7.5-7.2 = \log (y / 0.045-y)$
- $0.3 = \log(y / 0.045-y)$ → antilog of $0.3 = 2 = y / 0.045-y$
- $Y = 0.09 - 2y$ → $3y = 0.09$
- $Y = 0.9/3 = 0.03\ M = [HPO_4^{-2}] = [A^-]$
- $[H_2PO_4^-] = [HA] = 0.045 - 0.03 = 0.015\ M$

- No. of moles of A^- = M x V = 0.03 x 0.01 = 0.003 moles
- No. of moles of HA= M x V = 0.015 x 0.01 = 0.0015 moles

You are provided with concentrated (15M) H_3PO_4 and solution of 1.5 M NaOH .

Calculations:

- Start with **0.0045 mole** of H_3PO_4 and add 0.0045 moles of NaOH to titrate H_3PO_4 completely to give $H_2PO_4^-$ (HA) , then add 0.003 moles of NaOH to titrate $H_2PO_4^-$ to give HPO_4^{-2} (A^-)

$$H_3PO_4 \xrightarrow{OH^-} H_2PO_4^- \xrightarrow{OH^-} HPO_4^-$$

- No. of moles needed of NaOH= 0.0045+0.003= 0.0075 moles
- Volume of NaOH needed= no.of moles / M = 0.0075/ 1.5 = 0.005 L =**5 ml**
- Volume of H_3PO_4 needed =no.of moles / M = 0.0045/ 15 =0.0003 L = **0.3 ml**

→ Add 5ml of NaOH to the 0. 3 ml of concentrate H_3PO_4, mix ; then add sufficient water to bring the final volume to 0.1 liters (100 ml), and check the pH

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You are provided with solid NaH_2PO_4(HA) and solid NaOH

Calculations

- Start with **0.0045 mole** of NaH_2PO_4 and add **0.003** moles of NaOH to titrate to titrate NaH_2PO_4 to give Na_2HPO_4 (A^-)

- Wt of NaH_2PO_4 needed = no.of moles x mwt =0.0045 x 141.98 = **0.638 g**

- Wt of NaOH needed = no. of moles x mwt = 0.003 x 40 =**0.12 g**

- Dissolve the NaH_2PO_4 and NaOH in some water, mix ; then add sufficient water to bring the final volume to 0.1 liters (100 ml), and check the pH

You are provided with solid Na_3PO_4 and 2 M solution of HCL

- Start with **0.0045 mole** of Na_3PO_4 and add 0.0045 moles of HCl to titrate Na_3PO_4 completely to give Na_2HPO_4 (A^-), then add **0.0015** moles of HCl to titrate Na_2HPO_4 to give NaH_2PO_4(HA)
- No. of moles needed of HCl= 0.0045+0.0015= 0.006 moles
- Volume of HCl needed= no.of moles / M = 0.006/ 2= 0.003 L =**3 ml**
- Wt of Na_3PO_4 needed = no.of moles x mwt =0.0045 x 380.12 = **1.71 g**

→Dissolve 1.71 g of Na_3PO in some water, mix ; then add 3 ml of HCl. Finally, add sufficient water to bring the final volume to 0.1 liters (100 ml), and check the pH

You are provided with solid NaH_2PO_4 (HA) and Na_3PO_4

- The NaH_2PO_4 (HA) and Na_3PO_4 react to from Na_2HPO_4 (A^-). The **NaH_2PO_4 acts as an acid** and the **Na_3PO_4 acts as a base .**

$$H_2PO_4^- + PO_4^{3-} \leftrightarrows 2\ HPO_4^-$$

- **Note that each mole of NaH_2PO_4 and Na_3PO_4 yields 2 moles of Na_2HPO_4 →** Thus to produce 0.003 mole of Na_2HPO_4, 0.0015 mole of NaH_2PO_4 and 0.0015 mole of Na_3PO_4 are required.
  ** But, in addition to the 0.003 mole of Na_2HPO_4, the final solution contains 0.0015 mole of NaH_2PO_4.
  Therefore , dissolve 0.0030 mole of NaH_2PO_4 and 0.0015 mole of Na_3PO_4 in water .

- Of the original 0.003 mole of NaH_2PO_4 , 0.0015 mole reacts with the Na_3PO_4 to produce 0.0030 mole of Na_2HPO_4, leaving 0.0015 mole as NaH_2PO_4 .
  -You need 0.0015 mole of k3PO4 .

- Wt of Na_3PO_4= no.of moles × mwt = 0.0015 x 380.12 = **0.57 g**

- Wt of NaH_2PO_4 = no. of moles x mwt = 0.003 x141.96 = **0.425 g**

- Dissolve the NaH_2PO_4 and Na_3PO_4 in some water, mix, then add sufficient water to make 0.1 liters (100 ml) and check the pH