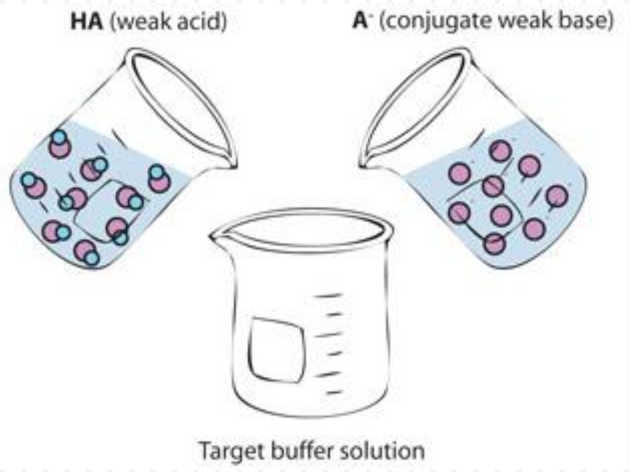
Preparation Of Buffer Solutions By Different Laboratory Ways



BCH 312 [Practical]

Dissociation of Triprotic acid

- **Triprotic acid** is acid that contain three hydrogens ions.
- It dissociates in solution in three steps, with three Ka values.
- **phosphoric acid** is an example of triprotic acid .

- It dissociates in solution as following:

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

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

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

preparation of Buffer by several ways:

For example if you asked to prepare sodium phosphate buffer [NaH_2PO_4 / Na_2HPO_4]

You can prepare it by:

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 **Na_2HPO_4** plus **NaH_2PO_4** by adding **HCL**.
6. By mixing **Na_3PO_4** and **NaH_2PO_4** in the proper proportions.

HCl

'donate H^+'

H_3PO_4

$H_2PO_4^-$

HPO_4^{2-}

PO_4^{3-}

NaOH

'accept H^+'

Example: **Prepare 0.1 liters of 0.045 M sodium phosphate buffer, pH=7.5, [pka_1= 2.12, pka_2 = 7.21 and pka_3 = 12.30]**

a) From concentrated (15M) H_3PO_4 and solution of 1.5 M NaOH .
b) From solid NaH_2PO_4 and solid NaOH.

Calculations:

1st , write the equations of Dissociation of phosphoric acid and the pka of corresponding ones:

Because phosphoric acid [H_3PO_4] has (Triprotenation : it has 3 dissociation phases) so,

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

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

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

Regardless of which method is used , the first step involves calculating number of moles and amounts of the two ionic species in the buffer

2nd , choose the pka value which is near the pH value of the required buffer, to be able to know the ionic species involved in your buffer:

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

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

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

The pH of the required buffer [pH =7.5] is near the value of **pka_2** , 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 }

Note :
$[A^-] = HPO_4^{-2}$
$[HA] = H_2PO_4^-$

3rd, **calculate No. of moles for the two ionic species in the buffer:**

pH =pKa2 + log [HPO42-] / [H2PO4-] ➔ Note that : [A-] = HPO42-, [HA] = H2PO4-

- Since the buffer concentration is 0.045M, so 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 for both sides

2=(y / 0.045-y) ➔ y= 0.09 -2 y ➔ 3 y = 0.09 ➔ y= 0.09/3 = 0.03M ➔ conc. of [HPO42-] = [A-] = y

So, conc. of [H2PO4-] =[HA] = 0.045 –y = 0.045-0.03 = 0.015 M

- **Now found the number of mole for the two ionic species in the buffer:**

No. of moles of = HPO42-(A-) = M x V = 0.03 x 0.1 = **0.003 moles.**

No. of moles of H2PO4-(HA)= M x V = 0.015 x 0.1 = **0.0015 moles**.

Note: Total no. of moles of phosphate buffer = M x V= 0.045 x 0.1 = **0.0045 moles**.

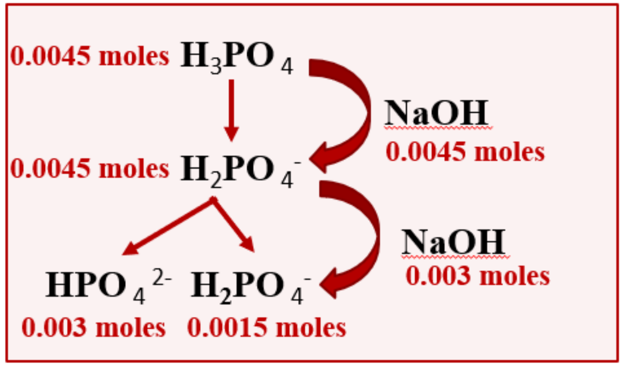
Now, to prepare the required buffer:
a) From concentrated (15M) H_3PO_4 and solution of 1.5 M NaOH .

Remember that the two ionic species involved in the buffer are:

$$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{2-}$$

Calculations:

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



- **No. of moles needed of NaOH**= 0.0045+0.003= **0.0075 moles**

- Volume of **NaOH** needed(L)= no.of moles (of NaOH) /M (of NaOH) = 0.0075/ 1.5 = 0.005 **L** =**5 ml**

- Volume of **H_3PO_4** needed(L) =no.of moles (of H3PO4) / M (of H3PO4) = 0.0045/ 15 =0.0003 **L** = **0.3 ml**

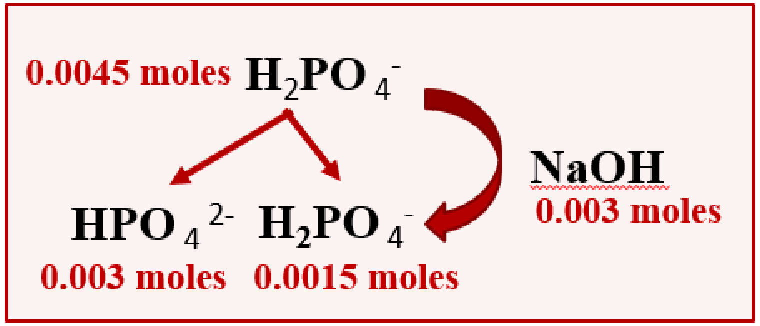
- → Add **5ml** of NaOH to the **0.3 ml** of concentrate H_3PO_4, mix ; then add sufficient water to bring the final volume to 0.1 liters (100 ml), and check the pH.

b) From solid NaH2PO4 and solid NaOH.

Remember that the two ionic species involved in the buffer are:

$$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{2-}$$

- **Calculations**



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

- Weight in grams of **NaH_2PO_4** needed = no.of moles x MW =0.0045 x 119.98 = **0.54 g**
- Weight in grams of **NaOH** needed = no. of moles x MW = 0.003 x 40 = **0.12 g**

- Dissolve the **0.54 g** of NaH_2PO_4 and **0.12 g** of NaOH in some water, mix ; then add sufficient water to bring the final volume to 0.1 liters (100 ml), and check the pH

Because we start with solid , We convert moles to grams not volume

Practical Part

Objective:

- To learn how to prepare a buffer by different laboratory ways.

Method:

Prepare 0.1 litersof 0.045 M sodium phosphate buffer, pH=7.5,

[pKa1= 2.12, pKa2 = 7.21 and pKa3 = 12.30]:

a) **From concentrated (15M) H_3PO_4 and solution of 1.5 M NaOH:**

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.

b) From solid $NaH_2PO_4$and solid NaOH:

Dissolve the **0.54g** of **NaH_2PO_4**and **0.12g** of **NaOH** in some water, mix ; then add sufficient water to bring the final volume to 0.1 liters(100 ml), and check the pH.

H.W

1) Prepare 100 ml of 0.045 M sodium phosphate buffer, pH=7.5,
[pka1= 2.12, pka2 = 7.21 and pka3 = 12.30]: (MW of Na2HPO4= 142, MW of Na3PO4= 164)

c) You are provided with solid Na_2HPO_4 and 2M solution of HCl.

d) You are provided with solid Na_3PO_4 and 2 M HCL .

2) Prepare 500 ml of 0. 3 M sodium phosphate buffer, pH=2.5,
[pka1= 2.12, pka2 = 7.21 and pka3 = 12.30]:

a) You are provided with solid Na_2HPO_4 and 5M (HCl or NaOH).

b) You are provided with 2M H_3PO_4 and 5M (HCL or NaOH) .