Panel 1

Goal: Prepare a buffer with an initial pH of 6.85. The buffer must be able to consume 0.0010 moles of strong base with a maximum change in pH of 0.20 units. The following reagents are available to you:

Solutions: 6.0 M HCl, 6.0 M H_3PO_4, 6.0 M CH_3COOH, 6 M NaOH

Solids: $NaHCO_3$, $Na_3PO_4 \cdot 12H_2O$, Na_2CO_3, Na_2HPO_4, $CH_3COONa \cdot 3H_2O$

Which reagent(s) will you use and why?

There are several choices, each involving either an $H_2PO_4^-/HPO_4^{2-}$ buffer, or an H_2CO_3/HCO_3^- buffer as these have a suitable pka.

$NaHCO_3$ + HCl (converting some HCO_3^- to H_2CO_3)

Na_2HPO_4 + HCl (" " HPO_4^{2-} to $H_2PO_4^-$)

H_3PO_4 + NaOH (" all H_3PO_4 to $H_2PO_4^-$ & HPO_4^{2-})

$Na_3PO_4 \cdot 12H_2O$ + HCl (" " PO_4^{3-} to $H_2PO_4^-$ & HPO_4^{2-})

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Panel 2

How many grams of NaH_2PO_4 and Na_2HPO_4 are needed to make this buffer?

For original solution

$$6.85 = 7.20 + \log\frac{(\text{moles } HPO_4^{2-})_0}{(\text{moles } H_2PO_4^-)_0}$$

$$\frac{(\text{moles } HPO_4^{2-})_0}{(\text{moles } H_2PO_4^-)_0} = 0.4467$$

$$(\text{moles } HPO_4^{2-})_0 = 0.4467 \times (\text{moles } H_2PO_4^-)_0$$

For limit

$$7.05 = 7.20 + \log\frac{\text{moles } HPO_4^{2-}}{\text{moles } H_2PO_4^-}$$

$$\frac{\text{moles } HPO_4^{2-}}{\text{moles } H_2PO_4^-} = 0.7079$$

$$\frac{(\text{moles } HPO_4^{2-})_0 + 0.001}{(\text{moles } H_2PO_4^-)_0 - 0.001} = 0.7079$$

$$\frac{0.4467 \times (\text{moles } H_2PO_4^-)_0 + 0.001}{(\text{moles } H_2PO_4^-)_0 - 0.001} = 0.7079$$

$(\text{moles } H_2PO_4^-)_0 = 6.54 \times 10^{-3}$ → 0.785 g NaH_2PO_4

$(\text{moles } HPO_4^{2-})_0 = 2.92 \times 10^{-3}$ → 0.415 g Na_2HPO_4

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Panel 3

The combined concentrations of HPO_4^{2-} and $H_2PO_4^-$ must be greater than 0.010 M but less than 0.020 M. Given your answer to the previous problem, to what range of volumes can you add the Na_2HPO_4 and NaH_2PO_4?

$(\text{moles } HPO_4^{2-})_0 + (\text{moles } H_2PO_4^-)_0 = \text{total moles}$

$2.92 \times 10^{-3} + 6.54 \times 10^{-3} = 9.46 \times 10^{-2}$ moles

$$\frac{9.46 \times 10^{-2} \text{ mol}}{0.01 \text{ mol/L}} = 9.46 \text{ L}$$

$$\frac{9.46 \times 10^{-2} \text{ mol}}{0.02 \text{ mol/L}} = 4.73 \text{ L}$$

} any volume in here will work

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