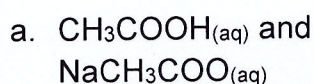


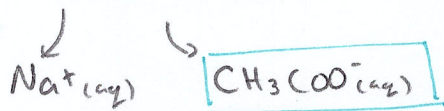
Buffer Solutions

- * • A **buffer** is a solution that can resist a change in pH when a moderate amount of a strong acid or strong base is added
- * • A buffer solution is created when a solution contains approximately equal amounts of a conjugate acid-base pair in relatively large amounts
 - To have a conjugate acid-base pair in equal amounts, only weak acids/bases can be present in a buffer solution.
 - Strong acids/bases cannot be present in a buffer solution
- EXAMPLE: When mixed in equal amounts, indicate which pair of chemicals can form a buffer solution.



↳ $\text{CH}_3\text{COOH}_{(aq)}$ is a weak acid

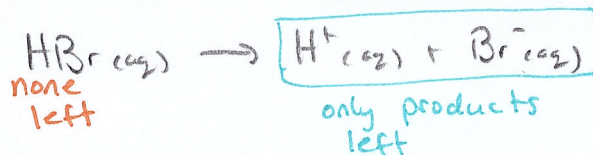
↳ $\text{NaCH}_3\text{COO}_{(aq)}$ is ionic & aqueous



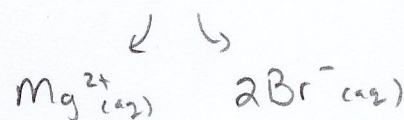
$\text{CH}_3\text{COOH}_{(aq)}$ & $\text{CH}_3\text{COO}^-_{(aq)}$ are both present as a conjugate acid/base pair
 ∴ buffer solution



↳ $\text{HBr}_{(aq)}$ is a strong acid
 ∴ it 100% ionizes



↳ $\text{MgBr}_{2(aq)}$ is ionic & aqueous

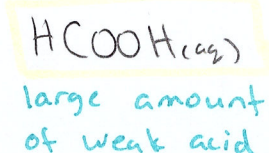


No conjugate acid/base pair present ∴ no buffer

- Even though strong acids and strong bases cannot be present in a buffer, they can be used to create a buffer. Consider the following situations.

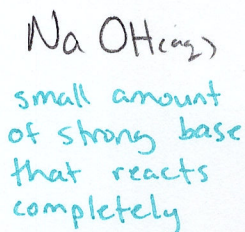
1. Adding a small amount of strong base to an excess amount of weak acid
 - Ex. A small amount of sodium hydroxide is added to methanoic acid

some left over



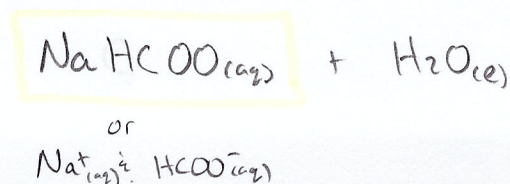
+

none left over



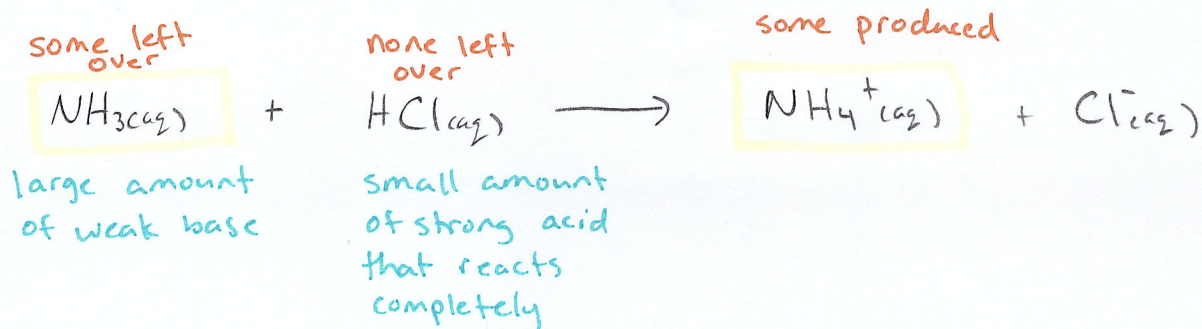
→

some produced



∴ $\text{HCOOH}/\text{HCOO}^-$ conjugate pair present to form a buffer

2. Adding a small amount of strong acid to an excess amount of weak base
- Ex. A small amount of hydrochloric acid is added to ammonia



$\therefore \text{NH}_3(\text{aq}) / \text{NH}_4^+(\text{aq})$ conjugate pair present to form a buffer

- How does a buffer solution resist a change in pH?

* Remember only OH^- ions and $\text{H}_3\text{O}^+ / \text{H}^+$ ions affect the pH/pOH of a solution

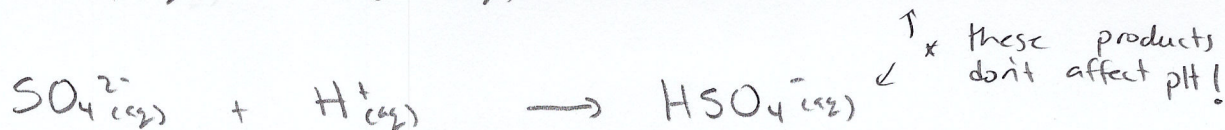
$$\text{pH} = -\log [\text{H}_3\text{O}^+] \quad ; \quad \text{pOH} = -\log [\text{OH}^-]$$

- When OH^- ions or $\text{H}_3\text{O}^+ / \text{H}^+$ are added to a buffer, the buffer converts or locks these ions into a form that does not affect the pH/pOH

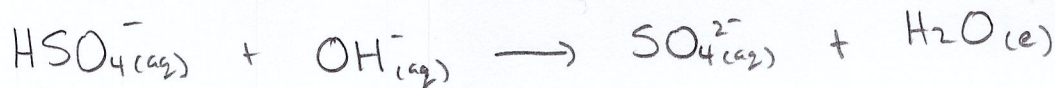
- Consider the buffer solution that contains $\text{NaHSO}_4(\text{aq})$ and $\text{Na}_2\text{SO}_4(\text{aq})$
 - By adding a strong acid to the buffer, the base component of the buffer will react with hydronium ions/hydrogen ions ($\text{H}_3\text{O}^+(\text{aq}) / \text{H}^+(\text{aq})$)



or



- By adding a base to the buffer, the acid component of the buffer will react with hydroxide ions ($\text{OH}^-(\text{aq})$) and convert them into a product that doesn't affect the pH.



* these products don't affect pH!

- However, when the components of the conjugate acid-base pair are completely consumed by the addition of a strong acid or strong base, the buffer fails and the pH changes dramatically. This is known as the **buffer capacity** and is the limit of the buffer solution to resist an change in pH

Now try the Practice Problems

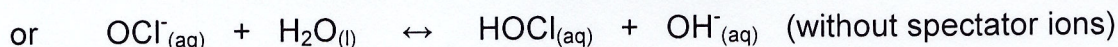
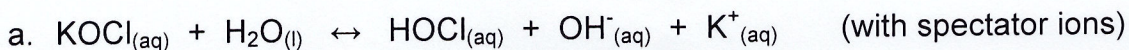
Practice Problems

- Which of the following solution pairs, when mixed in equal quantities, will form an effective buffer?
 - $\text{HNO}_{3(\text{aq})}$ and $\text{NaNO}_{3(\text{aq})}$
 - $\text{C}_6\text{H}_5\text{COOH}_{(\text{aq})}$ and $\text{NaC}_6\text{H}_5\text{COO}_{(\text{aq})}$
 - $\text{NH}_{3(\text{aq})}$ and $\text{NH}_4\text{Cl}_{(\text{aq})}$
 - $\text{HClO}_{4(\text{aq})}$ and $\text{NaOH}_{(\text{aq})}$
 - $\text{NaCl}_{(\text{aq})}$ and $\text{HCl}_{(\text{aq})}$
 - $\text{H}_3\text{PO}_{4(\text{aq})}$ and $\text{K}_2\text{PO}_{4(\text{aq})}$
 - $\text{NH}_4\text{CN}_{(\text{aq})}$ and $\text{HCN}_{(\text{aq})}$
- Write out the acid-base reaction for $\text{KOCI}_{(\text{aq})}$.
 - Does this solution create an effective buffer? Explain.
- Write the reaction of a carbonic acid/hydrogen carbonate ion buffer when a small amount of
 - $\text{HCl}_{(\text{aq})}$ is added.
 - $\text{NaOH}_{(\text{aq})}$ is added.
- What happens if a large/excess amount of a strong acid or base is added to a buffer?

Answers

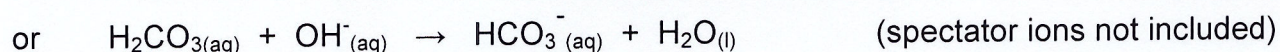
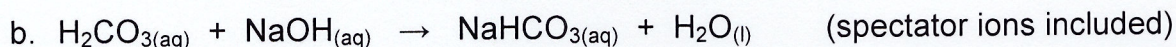
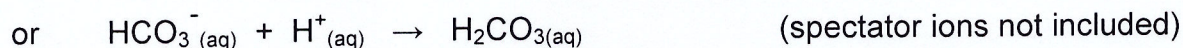
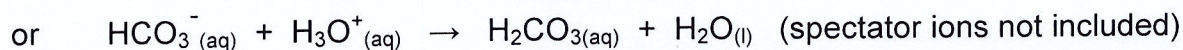
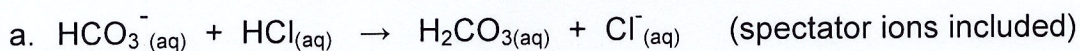
1. b, c, g

2.



b. A buffer solution contains approximately *equal amounts* of a conjugate acid-base pair. Since $\text{OCl}^-_{\text{(aq)}}$ is a weak base, the solution containing $\text{KOC}_{\text{l(aq)}}$ *does* have a conjugate acid present but only in very small amounts. Therefore, this solution will *not be* an effective buffer.

3.



Notice how the products produced in both reactions will not affect the pH/pOH because only $\text{H}^+/\text{H}_3\text{O}^+$ and OH^- ions can affect the pH/pOH.

4. Initially the buffer can resist a change in pH. However, when a large amount of strong acid or strong base is added, the buffer will reach its capacity and will fail, resulting in a dramatic change in pH.