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Buffer Chemistry Questions with Solutions

Q1. Why does a buffer solution resist any change in pH?
(a) They give unionised acid or base on reaction with acid or a base.
(b) Acids and bases in the buffer solutions are protected from attack by other ions
(c) They have an excess of H^+ or OH^- ions.
(d) They have a fixed pH value.
Answer: (a) A buffer solution resists any change in pH because they give unionised acid or base on reaction with acid or a base.

Q2. Which of the following mixture is an example of a buffer solution?
(a) $NaNO_2$ and HNO_2
(b) KCl and HCl
(c) NH_4NO_3 and HNO_3
(d) NaCl and NaOH
Answer: (a) $NaNO_2$ and HNO_2 mixture is an example of the buffer solution.

Q3. Which of the following mixture is not an example of an acidic buffer solution?
(a) Na_2CO_3 and H_2CO_3
(b) CH_3COONa and CH_3COOH
(c) $NaClO_4$ and $HClO_4$
(d) Na_3PO_4 and H_3PO_4
Answer: Mixture of $NaClO_4$ and $HClO_4$ is not an example of an acidic buffer solution.

Q4. A buffer solution is a mixture of
(a) Weak Acid and Strong Base
(b) Strong Acid and Weak Base
(c) Strong Acid and its conjugate base
(d) Weak Acid and its conjugate base
Answer: (d) Buffer solution is a mixture of a weak acid and its conjugate base.

Q5. What is the pH of a buffer solution?
(a) Same as its pKa value
(b) Same as its Ka value
(c) Can't be calculated
(d) None of the above
Answer: (b) The pH of a buffer solution is the same as its pKa value.

Q6. What is a buffer solution? Give an example of a buffer solution.
Answer: A buffer solution is a mixture of a weak acid and its conjugate base. It resists any change in the pH upon the addition of acidic or basic components.
Example: A mixture of acetic acid and sodium acetate.

Q7. What are the various types of buffer solutions?
Answer: There are two types of buffer solutions.
1. Acidic buffer solution
2. Basic Buffer solution

Q8. What is a basic buffer solution? Give an example of a basic buffer solution.
Answer: A basic buffer solution is a mixture of a weak base and its conjugate strong acid. It resists any change in the pH upon the addition of acidic or basic components.
Example: A mixture of ammonium hydroxide and ammonium chloride.

Q9. What is Henderson and Hasselbalch Equation? Give one limitation of the Handerson Equation.
Answer: Henderson and Hasselbalch proposed an equation that gives a relation between the pH or pOH and pKa or pKb and the ratio of the concentrations of the ionised chemical species.
$pH = pKa + \log10 ([A^-] / [HA])$
Here,
$[A^-]$ refers to the molar concentration of the conjugate base of the acid
[HA] refers to the molar concentration of the weak acid.

Limitation of Henderson and Hasselbalch Equation: It cannot be used for strong acids and strong bases.

Q10. Distinguish between an acidic buffer solution and a basic buffer solution.
Answer:

S. No.	Acidic Buffer Solution	Basic Buffer Solution
1.	An acidic buffer solution is a mixture of a weak acid and its conjugate strong base.	A basic buffer solution is a mixture of a weak base and its conjugate strong acid.
2.	Example: A mixture of acetic acid and sodium acetate.	Example: A mixture of ammonium hydroxide and ammonium chloride.
3.	Its pH is less than 7.	Its pH is more than 7.

Q11. Match the following

Column A	Column B
Acid	**A substance with one more proton than a base.**
Base	**A mixture of a weak acid or base and its salt.**
Conjugate Acid	**A substance with one less proton than an acid.**
Conjugate Base	**A substance that acts as a proton acceptor.**
Buffer Solution	**A substance that acts as a proton donor.**

Answer:

Column A	Column B
Acid	**A substance that acts as a proton donor.**
Base	**A substance that acts as a proton acceptor.**
Conjugate Acid	**A substance with one less proton than an acid.**
Conjugate Base	**A substance with one more proton than a base.**
Buffer Solution	**A mixture of a weak acid or base and its salt.**

Q12. What is buffering capacity?
Answer: Buffering capacity is the number of millimoles of an acid or a base to be added to one litre of buffer solution to change its pH by a unit.
Buffering capacity = Millimoles / (Δ pH)

Q13. What is the ratio of base and acid when the pH of the solution is equivalent to the pKa in the buffer solution? How will the result alter if the pKa is increased by unity?
Answer: According to the Henderson and Hasselbalch equation:
$pH = pKa + \log_{10} ([A^-] / [HA])$
Given that the pH of the solution is equal to the pKa.
It is only possible when the ratio of base to acid is equivalent to 1 as log 1 = 0.
If pKa is increased by unity, then the log (base/acid) must be equivalent to 1. Thus, the ratio of base to acid must be 10:1.

Q14. 100 ml of 0.1 M CH3COOH is mixed with 50 ml of 0.1 M NaOH solution, and the pH of the resulting solution is 5. What is the change in pH if 100 ml of 0.05 M NaOH is added to the above solution?
Answer: According to the Henderson and Hasselbalch equation:
$pH = pKa + \log_{10}([A^-] / [HA])$
$pH = pKa + \log_{10}(0.1 X 0.05 / 0.1 X 0.05)$
$5 = pKa$

When 100 ml of 0.05 M NaOH is added, the acid is completely neutralized, to form sodium acetate salt. The expression for the hydrogen ion concentration of a weak acid and strong base salt.
$pH = ½ (pKw + pKa + \log c)$
$pH = ½ (14 + 5 + \log (0.1 / 0.25)$
$pH = 8.8.$
Hence, the change in pH will be
$\Delta pH = 8.8 - 5$
$\Delta pH = 3.8.$

Q15. A specific buffer solution contains an equal concentration of X^- and HX. The Kb for X^- is $10^{-10.}$
What is the pH of the buffer solution?
Answer: According to the Henderson and Hasselbalch equation:
$pH = pKa + \log_{10}([A^-] / [HA])$
$pOH = pKb + \log_{10}([A^-] / [HA])$
Here the concentration of $[A^-]$ is equivalent to the [HA]
$\log_{10}([A^-] / [HA]) = \log_{10} 1$
$\log_{10}([A^-] / [HA]) = 0$
Putting value in the Henderson and Hasselbalch equation.
$pOH = pKb$
$pOH = \log 10^{-10}$
$pOH = 10$
Further, $pH + pOH = 14$.
Putting the value of pOH in the above equation.
$pH + 10 = 14$
$pH = 14 - 10$
$pH = 4.$

Practise Questions on Buffer

Q1. A 0.1 mole of CH_3NH_2 with Kb 5 X 10^{-4} is mixed with 0.08 mole of HCl and diluted to one litre. What is the $[H^+]$ concentration in the solution?

Answer: The reaction mixture contains unreacted methylamine and its hydrochloride salt.
Thus, it is a basic buffer solution.
The expression for the hydroxide ion concentration is
$[OH^-]$ = (Kb X [Base]) / [Conjugate acid]
Substitute values in the above expression.
$[OH^-] = (5 \times 10^{-4} \times 0.02) / 0.08$
$[OH^-] = 1.25 \times 10^{-4}$

But $[H^+] [OH^-] = Kw = 10^{-14}$

$\therefore [H^+] = 10^{-14} / [OH^-]$
$[H^+] = 10^{-14} / 1.25 \times 10^{-4}$
$[H^+] = 8 \times 10^{-11}$ M.

Q2. The pH of 0.1M solution of the following salts increases in the order of:
(a) $NaCl < NH_4Cl < NaCN < HCl$
(b) $HCl < NH_4Cl < NaCl < NaCN$
(c) $NaCN < NH_4Cl < NaCl < HCl$
(d) $HCl < NaCl < NaCN < NH_4Cl$
Answer: (b) The correct order is $HCl < NH_4Cl < NaCl < NaCN$.
Explanation: NaCN is a salt of a weak acid and strong base, so its pH is highest, while NaCl is a salt of strong acid and strong base, so its pH is lower than NaCN, while NH4CN is a salt of a weak acid and weak base, so its pH is lower than both NaCN and NaCl and HCl is a strong acid, so it has lowest pH.

Q3. What is $[H^+]$ in mol / L of a solution 0.20 M in CH_3COONa and 0.10 M in CH_3COOH? The Ka for CH_3COOH is 1.8×10^{-5}.
Answer: The ionisation of CH_3COOH and CH_3COONa takes place as follows:-
$CH_3COONa \rightarrow CH_3COO^- + Na^+$
$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$

Due to the presence of common CH_3COO^- ions, the equilibrium of the acid will shift towards the left (by Le Chateliers's principle)
As we know, $Ka = [CH_3COO^-] [H^+] / [CH_3COOH]$

Here the $[CH_3COO^-]$ = 0.2 M and $[CH_3COOH]$ = 0.1 M and Ka = 1.8×10^{-5}, and hence substituting the values in the above formula, we can get the value of concentration of $[H^+]$ ions.
$\therefore 1.8 \times 10^{-5} = [0.2] [H^+] / [0.1]$
$\therefore [H^+] = 9.0 \times 10^{-6}$ mol / L.

Q4. In a buffer solution containing an equal B^- and HB concentration, the Kb for B^- is 10^{-10}. What is the pH of the buffer solution?

Answer: Here, the Kb for B^- is 10^{-10}

$\therefore$ pKb = − $\log_{10}$ Kb

pKb = − $\log_{10}(10^{-10})$

pKb = 10

According to the Henderson and Hasselbalch equation:

pH = pKa + $\log_{10}([A^-] / [HA])$

pOH = pKb + $\log_{10}([A^-] / [HA])$

Here, the concentration of the salt and the acid is the same

$\therefore \log_{10} 1 = 0$.

$\therefore$ pOH = pKb = 10

And we know that pH + pOH = 14

pH = 14 − pOH

pH = 14 − 10

pH = 4.

Q5. The pH of a buffer solution containing 0.1 M CH_3COOH and 0.1 M CH_3COONa is 4.74. If 0.05 mole of HCl is added to one litre of this buffer solution, what will be the pH? Given Ka of CH_3COOH is equal to 1.8×10^{-5}.

Answer: According to the Henderson and Hasselbalch equation:

pH = pKa + $\log_{10}([A^-] / [HA])$

pH = pKa + $\log_{10}(0.1 / 0.1)$

pH = pKa

Given pKa = 4.74

When 0.05 moles of HCl are added to 1 L of the solution.

$CH_3COONa + HCl \rightarrow CH_3COOH + NaCl$

Initially:	0.1 M / 1lit = 0.1 mole	0.05	0.1 M / 1lit
Finally,	0.05 mole	0	0.15 mole

pH_{Now} = pKa + log [salt] / [acid] =

pH_{Now} = 4.74 + log 0.05 / 0.15

pH_{Now} = 4.74 − log3

pH_{Now} = 4.27.