

Basic buffer solutions

We are talking here about a mixture of a weak base and one of its salts - for example, a solution containing the weak base, ammonia, NH_3 and the salt, ammonium chloride, NH_4Cl .

Example: Calculate the pH of a solution containing $0.100 \text{ mol L}^{-1} \text{NH}_3$ and $0.0500 \text{ mol L}^{-1} \text{NH}_4\text{Cl}$?

$$K_a(\text{NH}_4^+) = 5.62 \times 10^{-10}$$

You may have learnt the (Henderson-Hasselbalch) buffer equation in class:

$$\text{pH} = \text{p}K_a + \log \frac{[\text{base}]}{[\text{acid}]}$$

But this equation is **NOT** on the supplied resource sheet so you either must rely on remembering it OR use the equation that is supplied....

That looks a bit unlikely as it is a K_a expression..... weak acid and all.... ☹️ Don't panic!

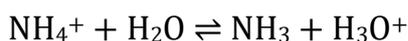
$$K_a = \frac{[\text{H}_3\text{O}^+][\text{A}^-]}{[\text{HA}]}$$

However, the way of doing this basic buffer calculation is to *re-think it* from the point of view of the ammonium ion rather than of the ammonia solution.

Once you have taken this different view-point, you can easily use the equation supplied by NCEA.

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{A}^-]}{[\text{HA}]}$$

The buffer will contain lots of unreacted ammonia molecules and lots of ammonium ions from the salt, NH_4Cl . These ammonium ions are weakly acidic.



Write the K_a expression for the ammonium ion.

$$K_a = \frac{[\text{NH}_3][\text{H}_3\text{O}^+]}{[\text{NH}_4^+]}$$

We assume $[\text{NH}_3]$ is the same concentration as the original ammonia solution and that $[\text{NH}_4^+]$ is the same as the concentration of the ammonium chloride.

Put the values into the K_a expression and calculate $[\text{H}_3\text{O}^+]$ and then the pH.

$$5.62 \times 10^{-10} = \frac{0.100 \times [\text{H}_3\text{O}^+]}{0.0500}$$

$$[\text{H}_3\text{O}^+] = (5.62 \times 10^{-10} \times 0.0500) \div 0.100 = 2.81 \times 10^{-10}$$

$$\text{pH} = -\log [\text{H}_3\text{O}^+] = -\log 2.81 \times 10^{-10} = 9.55$$

If you are looking for a way to calculate buffer composition, you can reverse the equation. Using known pH to calculate H_3O^+ and the known K_a , you can calculate the ratio of concentrations of the acid and conjugate base, necessary to prepare the buffer.

Alternatively..... using the buffer equation that you have memorised....

$$\text{pH} = \text{pK}_a + \log \frac{[\text{base}]}{[\text{acid}]}$$

$$\text{pH} = -\log 5.62 \times 10^{-10} + \log (0.100 / 0.0500)$$

$$\text{pH} = 9.25 + \log (0.100 / 0.0500)$$

$$\text{pH} = 9.25 + \log (2)$$

$$\text{pH} = 9.55$$

*Again, if you are looking for a way to calculate buffer composition, you can reverse the equation. Using known **pH** and known **pK_a** you can calculate the ratio of concentrations of the acid and conjugate base, necessary to prepare the buffer.*