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 mol L^{-1} NH_3 and 0.0500 mol L^{-1} NH_4Cl? $K_a(NH_4^+) = 5.62 \times 10^{-10}$

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

$$pH = pK_a + \log\frac{[base]}{[acid]}$$

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!

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

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.

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

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.

$$NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$$

Write the K_a expression for the ammonium ion.

$$K_a = \frac{[NH_3][H_3O^+]}{[NH_4^+]}$$

We assume $[NH_3]$ is the same concentration as the original ammonia solution and that $[NH_4^+]$ is the same as the concentration of the ammonium chloride.

Put the values into the K_a expression and calculate $[H_3O^+]$ and then the pH.

$$5 \cdot 62 \times 10^{-10} = \frac{0 \cdot 100 \times [H_3O^+]}{0.0500}$$

$[H_3O^+] = (5.62 \times 10^{-10} \times 0.0500) \div 0.100 = 2.81 \times 10^{-10}$

pH = $-\log [H_3O^+] = -\log 2.81 \times 10^{-10}$ = **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….

$$\mathrm{pH} = \mathrm{pK_a} + \log\frac{[\mathrm{base}]}{[\mathrm{acid}]}$$

pH = -log 5.62 x 10^{-10} + log (0.100 / 0.0500)

pH = 9.25 + log (0.100 / 0.0500)

pH = 9.25 + log (2)

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.*