Hello students and welcome to the course Physical Chemistry and Organic Chemistry CHC102 for the first year BSc.

In this course and this particular section, we will be looking at calculation of hydrolysis constant and degree of hydrolysis. After learning this course, you will be able to know what isdegree of hydrolysis and hydrolysis constant for different types of salts.

Hydrolysis constant is defined as the equilibrium constant for a hydrolysis reaction obtained by the application of law of mass action. It is represented by K subscript H.

Now there are four different types of salts:Salt of strong acid-strong base, salt of weak acid-strong base, salt of strong acid- weak base and salt of weak acid-weak base. Now when we look at the salt of strong acid and strong base, this particular salt does not undergo any hydrolysis. So the salts which actually undergo hydrolysis are the salts of weak acids and strong bases, salts of weak bases and strong acids and salts of weak acids and weak bases.

So we will go to each one of this one by one. Now coming to the salt of weak acids and strong bases the general hydrolysis reaction is represented as given in equation,Base that is A- reacts with water to give you HA (acid) and the hydroxide ion.

$$A^- + H_2O \leftrightarrow HA + OH^-$$ --------(1)

The hydrolysis constant is calculated using equation given by the formula

$$K_h = \frac{K_w}{K_a}$$ ----------(2)

where kW is the ionic Product of water and K is the dissociation constant of the acid that is being formed. The derivation you have already learned in the last modules.

.

Similarly, degree of hydrolysis is the fraction of the salt which has undergone hydrolysis when equilibrium is established.Now we all know that the salt of either weak acids or weak bases do not undergo hydrolysis completely, and for each salt the extent of hydrolysis varies and that's the reason why we calculate the degree of hydrolysis. It is represented by alpha and it is given by the formula

$$\alpha = \sqrt{\frac{K_w}{K_a\, C}}$$ ----------(3)

where again kW is the ionic product of water. The dissociation constant of the Acid is K_a and C is the concentration of salt that is taken.
Now let us use this to calculate a problem:
The problem is to calculate the hydrolysis constant and degree of hydrolysis of 0.625 molar sodium acetate, which is the salt of strong base and weak acid and K a of the weak acid,is given as 1.754×10^{-5}.

Now according to the equation below, hydrolysis constant is given by KH equal to kW upon K.

$$K_h = \frac{K_w}{K_a}$$

----------(2)

Now k_W that is the ionic product of water, it's a constant and the value of it is 10^{-14} and K_a of the acid as given in the problem is 1.754×10^{-5} .So substituting this data into the formula that is the equation (2) we get the final answer as 5.701×10^{-2} . So this is the hydrolysis constant of sodium acetate. When we look at it, it is 5.701×10^{-2} which means that the value is very very small.

Now coming to calculation of degree of hydrolysis we use equation (3) and the formula is already known to us.

$$\alpha = \sqrt{\frac{K_w}{K_a\, C}}$$

Ka is also known to us and C that is the concentration of the salt is 0.625M.
So substituting all these quantities and taking the square root of it we get alpha i.e. the degree of hydrolysis as 9.55×10^{-5}.

Next we go to the salt of weak bases and strong acids and all the salts of weak bases and strong acids undergo hydrolysis as given in equation (4) i.e.

$$B^+ + H_2O \leftrightarrow BOH + H^+$$

---------(4)

The hydrolysis constant for such salt is given by the formula

$$K_h = \frac{K_w}{K_b}$$ ----------(5)

where K_h is the ionic product of water and K_b is the dissociation constant of the weak base that is formed.

Degree of hydrolysis is given by the formula

$$\alpha = \sqrt{\frac{K_w}{C\,K_b}}$$ --------(6)

Let us use this in solving a problem.

Calculate the hydrolysis constant and degree of hydrolysis of 0.01 M ammonium chloride.

Now ammonium chloride is a salt of weak base and strong acid and the data given to us is the dissociation constant of the base which is 1.81×10^{-5}.We use equation (5) as we have written earlier and the equation (5) is

$$K_h = \frac{K_w}{K_b}$$

Where Kw is Ionic product of water, Kb is the dissociation constant of the base. Substituting the same in equation (5) we get the final answer as 5.53×10^{-10}

Calculation of degree of hydrolysis.This is given by equation (6) which is

$$\alpha = \sqrt{\frac{K_w}{C\,K_b}}$$

we get the final answer alpha as 7.43 x10^{-4}.

Now coming to the third type that is the salts of weak acids and weak bases. We represent the hydrolysis reaction as given in equation (7)

$$B^+ + X^- + H_2O \leftrightarrow BOH + HX$$

--------(7)

That is, it forms weak acid as well as weak base and the hydrolysis

constant is given by the formula

$$K_h = \frac{K_w}{K_a\,K_b}$$

----------(8)

where Ka is the dissociation constant of the acid and Kb is the dissociation constant of the base formed.

Similarly, the degree of hydrolysis is given by the formula

$$\alpha = \sqrt{\frac{K_w}{C\,K_a\,K_b}}$$

----------(9)

Let us also use this data to calculate a problem,

Calculate the hydrolysis constant and degree of hydrolysis of a decimolar solution of ammonium acetate. Ammonium acetate is a salt of weak acid and strong base Dissociation constant of weak acid and weak base,both are given to us and the ionic product of water is also given to us.

Using the equation (8) that we had written earlier

$$K_h = \frac{K_w}{K_a K_b}$$

-------(8)

And substitutuing all the values, we get K_h equal to 3.16 x10^{-4}.

Similarly, going for the calculation of degree of hydrolysis as given by the formula in equation (9)

$$\alpha = \sqrt{\frac{K_w}{C K_a K_b}}$$

----------(9)

Now using that equation (9), alpha is equal to root of k_w upon K_aK_b, which is nothing but root of KH. So instead of using root of k_w upon K_aK_b,. we can directly use the formula alpha equal to root of K_h and we have just calculated K_h.
So substituting

$$\alpha = \sqrt{K_h} = \sqrt{3.16x10^{-4}} = 0.0177$$

gives us the answer as 0.0177.
These are some of the books which have been referred.
Thank you.