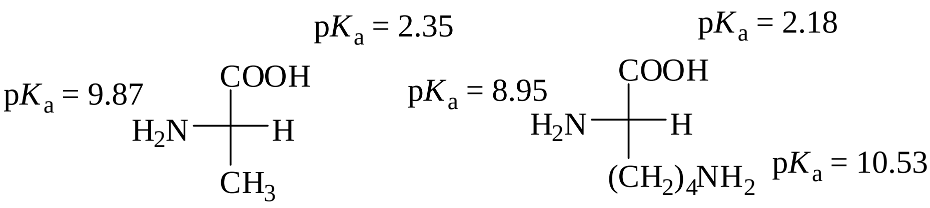
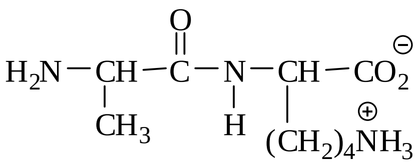
- Alanine (*ala*) and lysine (*lys*) are two amino acids with the structures given below as Fischer projections. The pK_a values of the conjugate acid forms of the different functional groups are indicated.



ala *lys*

Draw the structure of the dipeptide *ala-lys* in its zwitterionic form.



Would you expect the dipeptide to be soluble in water? Give a brief reason for your choice.

The presence of oxygen and nitrogen atoms and O-H and N-H groups would lead to strong H-bonding and ion-dipole forces in water and so the dipeptide is likely to be water soluble.

Would you expect the dipeptide to be acidic, neutral or basic? Give a brief reason for your choice.

There is a basic $-NH_2$ side chain on lysine. As there is a greater number of basic groups than acidic groups overall, it is likely to be basic.

Estimate the isoelectric point of the dipeptide.

The dipeptide has three ionizable groups – the amine function on the alanine (pK_a 9.87), the carboxylic acid group on the lysine (pK_a 2.18) and the amine group on the lysine side chain (pK_a 10.53).

The fully protonated form of the dipeptide has the two $–NH_2$ and the –COOH groups protonated and has a +2 charge. This form will exist at low pH. The full deprotonated form, the amine functions are not protonated and the carboxylic acid is deprotonated ($-COO^-$) giving the molecule a -1 charge.

ANSWER CONTINUES ON THE NEXT PAGE

At low pH, the protonated (+2) form dominates. As the pH is raised the group with the lowest pK_a (the carboxylic acid group) will become steadily deprotonated. At a pK_a of 2.18, there is a 50:50 mixture of the +2 and +1 forms. The latter having the carboxylic acid group deprotonated.

As the pH is raised further, the group with the next lowest pK_a (the alanine amine group) becomes steadily deprotonated. At a pK_a of 9.87, there is a 50:50 mixture of the +1 and neutral forms. The latter having the alanine mine group deprotonated.

As the pH is raised even more, the final group (lysine side-chain amine) becomes deprotonated. At a pK_a of 10.53, there is a 50:50 mixture of the neutral and -1 forms.

A pH of 9.87 gives a 50:50 mixture of +1 and neutral. A pH gives a 50:50 mixture of -1 and neutral. Hence, a pH intermediate between these values will give a solution predominately containing the neutral form. This is the isoelectric point:

$$\text{pI} = \frac{pk_{a1}+pk_{a2}}{2} = \frac{(10.53+9.87)}{2} = 10.2$$