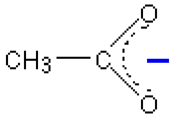
Chemguide – answers

ORGANIC ACIDS

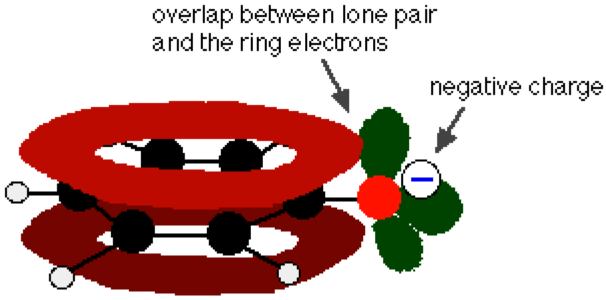
1. Any negative ion is made more stable if the charge can be spread around rather than being entirely on one atom. In the case of these ions, more stable means less likely to recombine with a hydrogen ion.

   In the case of the ethanoate ion, the negative charge is delocalised over the whole of the COO^- group. Using one of the diagrams from the Chemguide page, this can be shown as

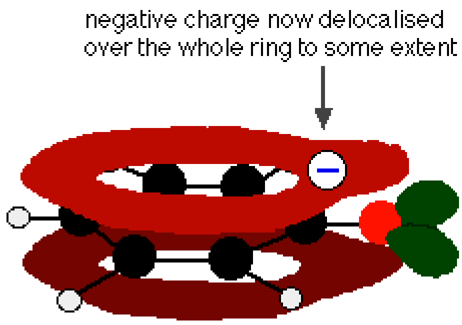
   

   Because the charge is spread out in this way, it isn't going to be as attractive to hydrogen ions as it would otherwise be, and so some of the ethanoic acid which ionises will stay ionised.

   In the phenoxide ion, the charge is again delocalised, this time by an interaction between one of the lone pairs on the oxygen and the ring electrons. Again using Chemguide diagrams:

   The delocalisation looks like this:

   This time, however, the delocalisation isn't as effective in preventing the ion from recapturing a hydrogen ion, because the oxygen is still the most electronegative element present, and the charge is still greatest around the oxygen. The delocalisation stabilises the ion to an extent, but not as much as in the ethanoate ion case. So phenol isn't as strong an acid as ethanoic acid.

   With the ethoxide ion, there is nothing to delocalise the charge, and it remains fully on the oxygen. That makes it very likely that an ethoxide ion will recapture any hydrogen ion which was lost, and go back to simple ethanol. So ethanol is only a very, very weak acid.

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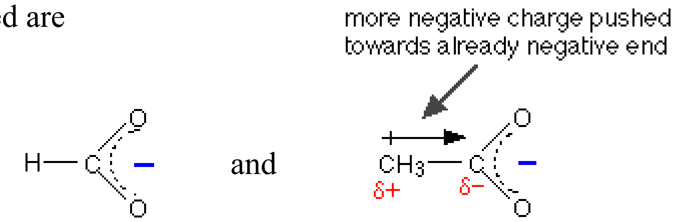
2. a) The lower the pK_a value, the stronger the acid. So methanoic acid is stronger than ethanoic acid.

   b) The two ions formed are



   Methyl groups have a tendency to "push" electrons away from themselves, and the result of that is to make the negative end of the ion even more negative. If it is more negative, it will be more likely to recapture a hydrogen ion that has been lost. That means that ethanoic acid will be a weaker acid than methanoic acid, because it won't stay ionised quite so readily.

3. Three of these acids have a halogen atom (F or Cl) in the chain. These are electronegative, and tend to pull electrons towards themselves. Pulling electrons away from the COO^- end makes that end less negative and so less attractive to hydrogen ions. The more you can decrease the negativeness around that end, the more likely the acid is to stay ionised, and so the stronger the acid.

   The weakest acid is therefore CH_3COOH, because there is nothing to pull electrons away from the COO^- end of the ion formed.

   The next weakest is CH_2ClCH_2COOH, because the effect of the electronegative element falls quite quickly the further it gets from the COO^- end.

   With the other two, fluorine is more electronegative than chlorine, and so is more effective at reducing the charge around the COO^- end. So $CH_2ClCOOH$ is next in the list, and CH_2FCOOH is the strongest of these acids.