3. This is a question about ants

The 'simplest' carboxylic acid is called methanoic acid and has formula HCOOH. It occurs naturally in ants and used to be prepared by distilling them! This gave rise to the earlier name for methanoic acid – *formic* acid – after the Latin word *formica* for ant.

When an ant bites, it injects a solution containing 50% by volume of methanoic acid. A typical ant may inject around 6.0×10^{-3} cm^3 of this solution.

A *Formica rufa* worker ant, just after biting the photographer!

(a) **i)** When you are bitten by an ant it does not inject you with all of its methanoic acid but keeps a little in reserve. Assuming a 'typical ant' injects 80% of its methanoic acid, what is the total volume of pure methanoic acid contained in a 'typical ant'?

ii) How many 'typical ant' ants would have to be distilled to produce 1.0 dm^3 of pure methanoic acid?

Bicarbonate of soda (sodium hydrogencarbonate) is often used to treat ant stings.

(b) **i)** Write the equation for the reaction between sodium hydrogencarbonate and methanoic acid.

ii) Given that the density of methanoic acid is 1.2 g cm^{-3}, how many moles of methanoic acid does the 'typical ant' inject?

iii) What mass of sodium hydrogen carbonate would be needed to neutralise completely the sting from this ant?

(c) As soon as the methanoic acid is injected it dissolves in water in the body to produce a solution of methanoic acid. Assuming that it dissolves immediately in 1.0 cm^3 of water in the body calculate the concentration of the methanoic acid solution that is formed.
[You may ignore the volume of the methanoic acid itself in this calculation.]

The pH of a solution is related to the concentration of hydrogen ions as follows:

$$pH = -\log [H^+]$$

where $[H^+]$ stands for the concentration of hydrogen ions in mol dm^{-3}.

(d) The pH of the methanoic acid solution produced above was 2.43. What is the concentration of hydrogen ions in this solution?

Methanoic acid is a weak acid and so is only partly ionised in solution

$$HCOOH_{(aq)} \rightleftharpoons HCOO^-_{(aq)} + H^+_{(aq)}$$

(e) Calculate the percentage of methanoic acid molecules which are ionised in this solution.

The *acid dissociation constant*, K_a, is a measure of how ionised a weak acid is. For methanoic acid it is defined by the following expression where again square brackets written round a formula mean the concentration of that substance in mol dm^{-3}

$$K_a = [HCOO^-][H^+] / [HCOOH].$$

(f) Calculate the acid dissociation constant for methanoic acid.