INTRODUCING CHEMICAL EQUILIBRIA

1. a) A closed system is one where no substances are either added or removed. Energy, however, can transfer to and from the system.

   b) At equilibrium, the quantities of everything present remain constant. The word "dynamic" shows that the forward and back reactions are still continuing (but with equal rates – you could leave this last bit until part (c).)

   c) The rates of the forward and back reactions become equal when dynamic equilibrium is reached.

   At the very beginning of the reaction, the rate of the A+B reaction is at its fastest, but falls as A and B are used up. Also at the beginning of the reaction, there isn't any C or D, and so the rate of their reaction is zero, but it speeds up as more and more C and D are formed.

   Eventually, the two rates become equal. Once that happens, the rate at which something is being formed is exactly the same as the rate at which it is being removed, and so there are no further changes in the quantities of things present in the system.

2. a) Most of the organic compound is there as un-ionised ethanoic acid, and relatively little as ethanoate ions. (Although you wouldn't be expected to know this, typically about 99% will be there as ethanoic acid at any one time, and about 1% as ethanoate ions.)

   b) Adding hydroxide ions will remove some of the hydroxonium ions from the right-hand side of the equilibrium. The fall in concentration of the hydroxonium ions will cause the back reaction to slow down, but won't immediately affect the rate of the forward reaction.

   The two reaction rates aren't equal any more, and so the system isn't in equilibrium. The ethanoic acid will continue to convert to ethanoate ions, lowering the concentration of ethanoic acid, and increasing the concentration of ethanoate ions, until the two rates become the same again.

   So eventually a new equilibrium will be reached with a lower concentration of ethanoic acid, and a greater concentration of ethanoate ions than before. The position of equilibrium will have moved further to the right.

   (If you add enough sodium hydroxide solution, you could essentially remove all of the hydroxonium ions as soon as they are formed, and so stop the back reaction entirely. That would turn the reversible reaction into a one-way process.)

   Well done if you worked this out!