ESTERS: PREPARATION

1. a) In the equation R and R' stand for hydrocarbon groups, and R and R' can be the same or different. R (but not R') can also be a hydrogen atom. (If you can't see why, think about what happens to the formula R'OH if R' is hydrogen!)

   The equation shows that any carboxylic acid will react with any alcohol (or phenol where the OH group is attached directly to a benzene ring) to give an ester and water. The reaction is reversible.

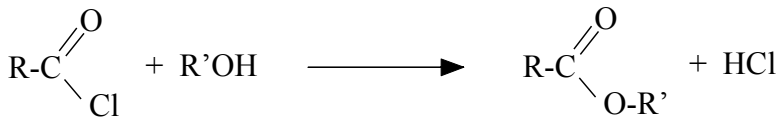
   b) Concentrated sulphuric acid.

   c) (i) All the organic compounds present are flammable.

   (ii) The smell is going to be a mixture of the smells of the ester and unreacted carboxylic acid and alcohol. If you pour the mixture into water, the ester is the least soluble and so floats on top, and that is what you will mainly smell.

   d) There are no hydrogen bonds between ester molecules, and so the boiling point of a small ester is likely to below the other components of the mixture, all of which do form hydrogen bonds. That makes it easy to remove the ester by distillation.

   (If you are wondering why this only really applies to small esters, imagine what happens as the acid gets bigger. Ethyl propanoate, for example, boils at 99°C because of the effect of the size of the molecule on the van der Waals dispersion forces. That is 21°C higher than the boiling point of the much smaller molecule ethanol, even if ethanol does the the advantage of additional hydrogen bonds. Even with ethyl ethanoate, your distillate will contain lots of ethanol as well as ethyl ethanoate because the boiling points are almost the same.)

2. a) 

   b) A very vigorous reaction between two colourless liquids producing steamy acidic fumes. The product is also a colourless liquid.

   c) (i) $CH_3CH_2COOCH_3$

   (ii) $CH_3COOCH_2CH_2CH_3$

   (iii) $CH_3COOC_6H_5$

   d) (i) Reactions of benzoyl chloride are slower than the reactions of, say, ethanoyl chloride, and its reaction with phenol is too slow. The phenoxide ion reacts with the benzoyl chloride much faster than phenol itself.

   (ii) Dissolve the phenol in sodium hydroxide solution.

(iii) $C_6H_5COCl + C_6H_5ONa \longrightarrow C_6H_5COOC_6H_5 + NaCl$

(You can show this in more detail if you want, but you are only asked for the equation rather than the full structures.)

3. a) The reactions involving acid anhydrides are slower, and the product other than the ester is a carboxylic acid rather than hydrogen chloride, so no steamy fumes are formed.

b) $(CH_3CO)_2O + CH_3CH_2OH \longrightarrow CH_3COOCH_2CH_3 + CH_3COOH$

(With acid anhydrides, it is often helpful to show the structures (particularly of the anhydride) in more detail. There is no reason why you can't do that in an equation if you want to.)