Chemguide – answers

CARBOXYLIC ACIDS: PREPARATION

1. a) The orange solution would turn green.

b) The reaction happens in two stages, first producing an aldehyde, and then further oxidation of that to the acid. You therefore need enough oxidising agent to complete the two stages, and you need to stop any aldehyde formed from escaping from the reaction flask before it can be oxidised to the acid.

c) $CH_3CH_2CH_2OH + 2[O] \longrightarrow CH_3CH_2COOH + H_2O$

d) (i) $CH_3CH_2CH_2OH + H_2O \longrightarrow CH_3CH_2COOH + 4H^+ + 4e^-$

(Look at the oxygen to start with. You need to gain an oxygen from somewhere, and the only source you are allowed to use under acid conditions is water. Now check the hydrogens. You have 4 spare ones, which must be formed as $4H^+$. Finally balance the charges by adding electrons.)

(ii) You first have to work out how many electrons you need to transfer. In this case, you need to transfer 12 – that will mean that the electrons cancel out when you add the half-equations together.

$$2 \times (\; Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O \;)$$
$$3 \times (\; CH_3CH_2CH_2OH + H_2O \longrightarrow CH_3CH_2COOH + 4H^+ + 4e^- \;)$$

$$3CH_3CH_2CH_2OH + 3H_2O + 2Cr_2O_7^{2-} + 28H^+ \longrightarrow 3CH_3CH_2COOH + 12H^+ + 4Cr^{3+} + 14H_2O$$

But you have hydrogen ions and water molecules on both sides of the equation. Tidy this up.

$$3CH_3CH_2CH_2OH + 2Cr_2O_7^{2-} + 16H^+ \longrightarrow 3CH_3CH_2COOH + 4Cr^{3+} + 11H_2O$$

e)

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$$
$$3 \times (CH_3CH_2CHO + H_2O \longrightarrow CH_3CH_2COOH + 2H^+ + 2e^-)$$

$$Cr_2O_7^{2-} + 14H^+ + 3CH_3CH_2CHO + 3H_2O \longrightarrow 2Cr^{3+} + 7H_2O + 3CH_3CH_2COOH + 6H^+$$

After the tidying up:

$$Cr_2O_7^{2-} + 8H^+ + 3CH_3CH_2CHO \longrightarrow 2Cr^{3+} + 4H_2O + 3CH_3CH_2COOH$$

I know this is tedious, but it is a key skill. Just take your time over it, and don't expect to get an answer instantly. If you try to rush it, you will make careless mistakes . When you have finished, check the balancing of everything, including the charges. If it all balances, then you know you are right.

2. a) Sodium or potassium cyanide.

(Care! The answer isn't "cyanide ions". Cyanide ions are a reactant, not a reagent. A reactant is one of the things on the left-hand side of the equation. Think of a reagent as being some named substance that you could get out of a bottle. You don't go to the shelf and get a bottle of cyanide ions! You can't have a bottle containing only negative ions.

This is quite confusing, because in some cases the words can both be used. For example, in a reaction involving bromine on the left-hand side of an equation, that is obviously a reactant. But you can also fetch a bottle of liquid bromine, and so it is also a reagent. You would refer to it as a reagent if you were handling the bottle, but a reactant if you were looking at the reaction in detail via the equation or mechanism. Don't get too worried about this!)

b) $CH_3CH_2Br + CN^- \longrightarrow CH_3CH_2CN + Br^-$

c) Heat under reflux with dilute hydrochloric acid, and then distill off the propanoic acid. (You could also hydrolyse it by refluxing it with sodium hydroxide solution, but then you have to remember to acidify it with hydrochloric acid before you distill it.)

d) Either: $CH_3CH_2CN + 2H_2O + H^+ \longrightarrow CH_3CH_2COOH + NH_4^+$

or: $CH_3CH_2CN + 2H_2O + HCl \longrightarrow CH_3CH_2COOH + NH_4Cl$

If you have used the sodium hydroxide hydrolysis, then you will need two equations.

Using ionic equations:

$$CH_3CH_2CN + H_2O + OH^- \longrightarrow CH_3CH_2COO^- + NH_3$$

$$CH_3CH_2COO^- + H^+ \longrightarrow CH_3CH_2COOH$$

Or a full equation:

$$CH_3CH_2CN + H_2O + NaOH \longrightarrow CH_3CH_2COONa + NH_3$$

You will still need the second ionic one for the formation of the propanoic acid.

e) propanenitrile