ALDEHYDES AND KETONES: OXIDATION

1. a)

Oxidising agent	Observations with	
	an aldehyde	a ketone
Potassium dichromate(VI) solution acidified with dilute sulphuric acid	Orange solution turns green (perhaps after warming)	No change
Tollens' reagent (containing the $[Ag(NH_3)_2]^+$ ion). Warm gently.	Colourless solution produces a grey precipitate or silver mirror on the test tube	No change
Fehling's solution or Benedict's solution. Warm gently.	Blue solution produces a dark red precipitate.	No change

b) Aldehydes are oxidised by replacing the hydrogen atom attached to the C=O bond by an -OH group (or an O^- ion if the reaction is done in alkaline solution). Ketones don't have a hydrogen atom attached to the C=O bond.

c) It is too powerful an oxidising agent, and has the ability to break carbon-carbon bonds. You would get much the same result with both aldehydes and ketones.

2. a) ethanoic acid (CH_3COOH)

b) $CH_3CHO + H_2O \longrightarrow CH_3COOH + 2H^+ + 2e^-$

c) $Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$

$3 \times (CH_3CHO + H_2O \longrightarrow CH_3COOH + 2H^+ + 2e^-)$

$Cr_2O_7^{2-} + 14H^+ + 3CH_3CHO + 3H_2O \longrightarrow 2Cr^{3+} + 7H_2O + 3CH_3COOH + 6H^+$

You multiply the ethanal equation by 3 to transfer 6 electrons. This isn't the final answer because there are water molecules and hydrogen ions on both sides of the equation. That needs simplifying.

$Cr_2O_7^{2-} + 8H^+ + 3CH_3CHO \longrightarrow 2Cr^{3+} + 4H_2O + 3CH_3COOH$

3. a) ethanoate ions (CH_3COO^-).

b) $CH_3CHO + 3OH^- \longrightarrow CH_3COO^- + 2H_2O + 2e^-$

This is a bit more of awkward to do than the equivalent equation in acid solution. Refer to http://www.chemguide.co.uk/inorganic/redox/equations2.html if you need more help.

c) $[Ag(NH_3)_2]^+ + e^- \longrightarrow Ag + 2NH_3$

(It doesn't matter whether you include the square brackets around the ion or not. I notice that I have used both forms on the Chemguide page!)

d) You need to multiply the second equation by 2 so that you are transferring 2 electrons. If you then add the two equations together, you will find that there isn't anything that occurs on both sides, so that is the final version.

$$2[Ag(NH_3)_2]^+ + CH_3CHO + 3OH^- \longrightarrow 2Ag + CH_3COO^- + 2H_2O + 4NH_3$$

4. Fehling's solution and Benedict's solution both contain copper(II) complexes in an alkaline solution. The copper(II) complex can be simplified to $Cu^{2+}_{(in\ complex)}$, and the electron-half-equation given as

$$2Cu^{2+}_{(in\ complex)} + 2OH^- + 2e^- \longrightarrow Cu_2O + H_2O$$

a) $CH_3CH_2CHO + 3OH^- \longrightarrow CH_3CH_2COO^- + 2H_2O + 2e^-$

(This is just the same as the ethanal equation from Q3(b), but with an extra CH_2 group.)

b) You can just add the two equations together, because both involve 2 electrons.

$$CH_3CH_2CHO + 2Cu^{2+}_{(in\ complex)} + 5OH^- \longrightarrow CH_3CH_2COO^- + Cu_2O + 3H_2O$$