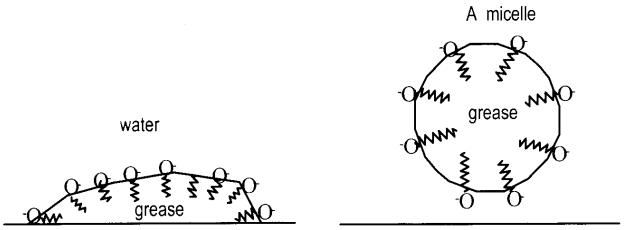
1. A solvent and solute will most easily combine in solution when they exhibit comparable secondary forces. A polar solvent would not effectively dissolve a non-polar solute as the hydrogen bonding between solvent molecules is far greater than the dispersion forces in the non-polar solute. A polar solvent will exhibit hydrogen bonding with the polar solute, dissolving and washing away the stain.

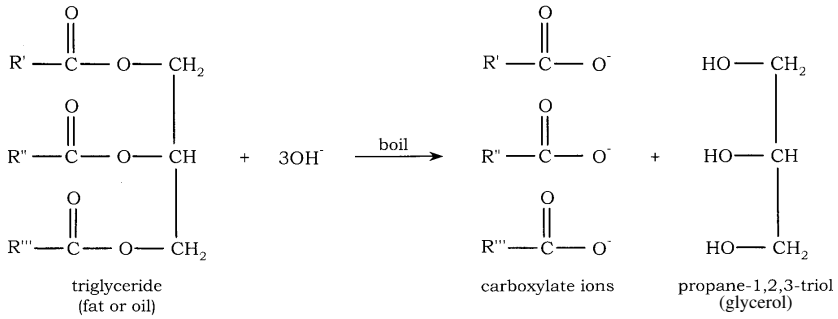
2.
   (a) Soaps and detergents consist of a non-polar hydrocarbon chain attached to a polar head. The non-polar end dissolves in the grease while the polar head dissolves in the water. With agitation, micelles form which can be washed away with the water.



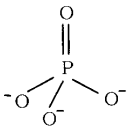

   (b) $M^{2+}_{(aq)} + 2RCOO^-_{(aq)} \rightarrow M(RCOO)_{2\,(s)}$

   (c) Soaps are much less effective than detergents in hard water because the $Mg^{2+}$ and $Ca^{2+}$ ions form a precipitate with the soap as shown above. Detergents do not form this precipitate and therefore remain as negative ions able to form micelles and clean away grease.

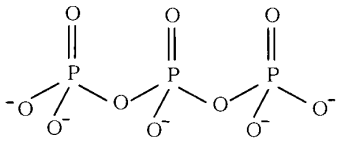
3. Soaps can be produced by boiling fats and oils in a highly alkaline solution:



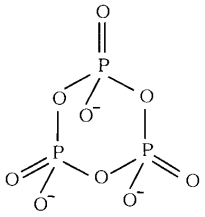

4.
   (a)



   (b)



   (c)



5.

(a) They produce slightly alkaline conditions, which are favourable for detergent action.
They remove free hard water ions from the water by forming water-soluble complex ions with them.
They act as deflocculants to keep clay particles in suspension so they don't settle back on whatever is being washed.

(b) It provides nutrients for plants in a soluble form.

(c) The growth of algae is increased by additional nutrients in the water, and a layer is formed over the surface of bodies of water, causing underwater plants which photosynthesise to die. (The increase of nutrients is called eutrophication).

6.

(a) Coloured stains can be oxidised to form colourless products. Hypochlorites, hypochlorous acid and chlorine which exist in equilibrium in aqueous solution are all oxidising agents.

(b) Lowering pH increases the amount of $H^+$ in solution. The $H^+$ forms hypochlorous acid with the hypochlorite ions, reducing hypochlorite. Chlorine and hypochlorous acid are in equilibrium:
$Cl_2 + H_2O \rightleftharpoons HOCl + H^+ + Cl^-$
Increasing hypochlorous acid and $H^+$ will cause the equilibrium position of the above reaction to move to the left, increasing chlorine.

7.

(a) Enzymes are able to remove stains even at low temperature
Enzymes may easily break down biological stains such as blood and sweat
Enzymes assist in the breakdown of proteins, fats and oils and can digest 'fine fluff' cellulose

(b) Enzymes are proteins. Changes in pH and temperature can change the 3D structure of proteins, denaturing them.

8.

(a) (answer needs to include at least 3 equations for full marks)
Solid oxygen bleaches work by releasing hydrogen peroxide, which decomposes to release oxygen.
$2H_2O_2 \rightarrow 2H_2O + O_2$
Both hydrogen peroxide and oxygen can act as oxidising agents, themselves being reduced.
$H_2O_2 + 2H \rightarrow + 2e^- \rightarrow 2H_2O$
The oxidation number of oxygen changes from -1 to -2, hence it is reduced.
$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$ (acidic conditions)
$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$ (neutral or alkaline conditions)
The oxidation number of oxygen changes from 0 to -2, hence it is reduced.

(b) Solid oxygen bleaches dissolve in water to release hydrogen peroxide much faster in hotter water, hence are more effective.