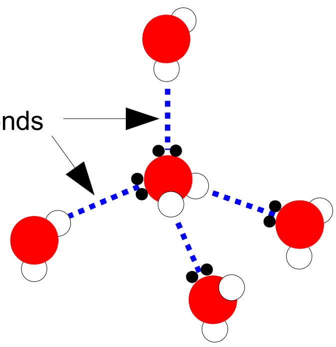
MOLECULAR STRUCTURES

1. a) All of these are broken *except* covalent bonds.

If you included covalent bonds, consider yourself in disgrace! Boiling water does *not* produce a mixture of hydrogen and oxygen atoms.

If you only mentioned hydrogen bonds, don't forget that in all molecular substances there will be attractions due to van der Waals dispersion forces, and for any molecule with a permanent dipole (which water does have) there will also be dipole-dipole interactions.

b)



Unless you are told that you only need to draw a few molecules, you should make clear in words that this is only a small part of the overall structure. You must show the bonding between the water molecules as hydrogen bonds, and with a simplified diagram with only a few water molecules, you should also show the lone pairs on the oxygen ends of the hydrogen bonds.

c) The hydrogen bonding in ice leads to a very open structure with wasted space in it. When the hydrogen bonds are broken as the ice melts, the water molecules get closer together. That means that ice is less dense than water, and so will float on the water.

2. a) (i) The only intermolecular forces in propane are van der Waals dispersion forces. Because propane is a small molecule, these forces are also small, and so not much energy is needed to break them. At room temperature the molecules have too much energy for these weak forces to hold them together as a liquid.

(ii) In order to make propane molecules mix with water molecules, you have to break the weak dispersion forces between the propane molecules, and also the stronger hydrogen bonds between water molecules. This needs energy. The new attractions between propane and water molecules are only weak dispersion forces, and so not much energy would be released on mixing.

The energy pay-back on mixing isn't enough to break the water molecules away from each other.

b) In this case, the only forces involved both with the pure substances and the solution are dispersion forces. The energy that you need to put in to separate the molecules in the individual compounds is much the same as you get back when the solution is formed.

c) (i) As well as dispersion forces, ethanol also has dipole-dipole interactions and hydrogen bonding. The total of these is much greater than just the dispersion forces in propane, and enough energy is needed to break them that ethanol remains a liquid at room temperature.

(ii) More energy is needed to break the ethanol molecules away from each other than in the propane case mainly because of the hydrogen bonding. But you also get more energy released when the ethanol forms a solution in water. That is because the ethanol can form hydrogen bonds with the water.

d) Pentan-1-ol also forms hydrogen bonds with water, but obviously only at the -OH end of the molecule. The "tail" of the molecule can only form weak van der Waals dispersion forces with the water molecules. But the tail has to fit between the water molecules, and a lot of hydrogen bonds between water molecules get broken in the process. Breaking all of these costs energy, but all you get back is a small amount from the new dispersion forces. It isn't energetically profitable for the pentan-1-ol to dissolve to any extent.

3. Each of these is a polymer with long chains of carbon atoms with hydrogens attached. HDPE has virtually unbranched chains, and these can lie close together. That allows the van der Waals dispersion forces to work well.

   LDPE has lots of short branches along the chains, and these stop the chains from lying tidily close to each other. That means that LDPE has weaker dispersion forces, and so is less strong and has a lower melting point than HDPE. Because the chains don't pack so efficiently, it also has a lower density.

4. Iodine consists of I_2 molecules, and the only attractions between the molecules are van der Waals dispersion forces. There are enough electrons in the I_2 molecule to make the temporary dipoles creating the dispersion forces strong enough to hold the iodine together as a solid. But they aren't all that strong, and so the solid has a low melting point and boiling point.

   It is almost insoluble in water because the only attractions between water molecules and iodine molecules are dispersion forces. But in order to get the iodine molecules in between the water molecules you would have to break hydrogen bonds in the water. This costs too much energy which can't be recovered from the new attractions between water and iodine.

   It dissolves in organic solvents such as hexane because, in this case, all you have to do is break the dispersion forces in the iodine and the hexane, and replace them by similar forces between the iodine and hexane.

   Iodine doesn't conduct electricity because it doesn't have any mobile delocalised electrons.