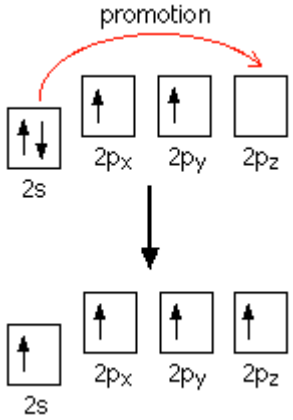
BONDING IN METHANE AND ETHANE

1. a) A carbon atom has the electronic structure $1s^2 2s^2 2p_x^1 2p_y^1$. One of the 2s electrons is promoted by moving it into the slightly higher energy $2p_z$ orbital to give the structure $1s^2 2s^1 2p_x^1 2p_y^1 2p_z^1$.

   You could equally well show this with the diagram



   b) Hybridisation means reorganising the electrons in the two different sorts of 2-level orbitals (s and p) into 4 orbitals with the same shape and energy. These are called sp^3 hybrids.

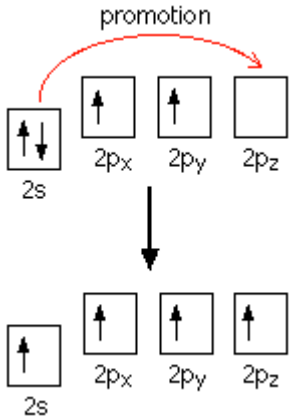
   c) Each hybrid orbital on the carbon overlaps in space with a $1s^1$ orbital on a hydrogen atom to form a molecular orbital containing both electrons.

   There is nothing much to be gained by drawing a diagram for this unless you want to. If you do, make sure that you use the term "molecular orbital", and say (or show) that each molecular orbital contains 2 electrons.

   d) A diagram showing the shapes and arrangement of the hybrid orbitals will probably help here.

   The four sp^3 hybrid orbitals arrange themselves as far apart in space as possible pointing towards the corners of a tetrahedron. This shape doesn't change when the hydrogen atoms form the molecular orbitals.

2. You need to go through exactly the same process as above, first showing promotion:

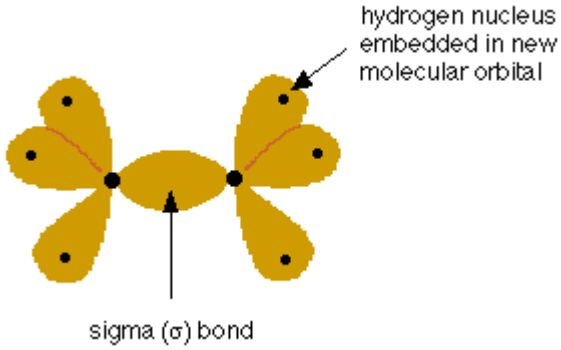


Then each carbon hybridises to form sp^3 hybrid orbitals.

Three of those hybrid orbitals on each carbon atom overlap in space with the $1s^1$ orbital from a hydrogen atom to give molecular orbitals joining the carbons and the hydrogens.

The remaining sp^3 orbital on each of the two carbon atoms overlap to give a molecular orbital linking the two carbons.

If you want to, you could draw a diagram like this:



You could use the term "sigma bond" if you wished, but you weren't specifically asked for it in the question. All the bonds shown in the diagram are actually sigma bonds, not just the one between the two carbons.