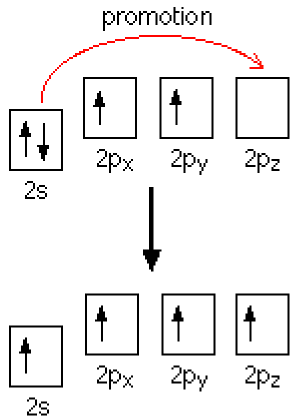
Chemguide – answers

BONDING IN ETHENE

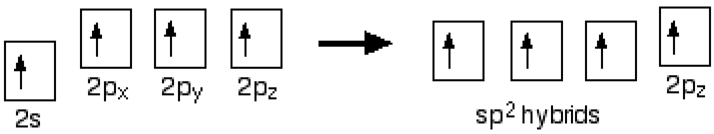
1. a) $1s^2 2s^2 2p_x^1 2p_y^1$.

b) One of the 2s electrons is promoted by moving it into the slightly higher energy $2p_z$ orbital to give the structure $1s^2 2s^1 2p_x^1 2p_y^1 2p_z^1$.

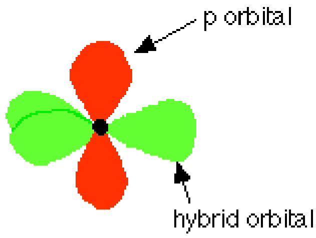
Or with a diagram:



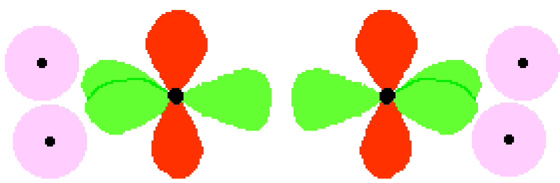
c) In the case of ethene, each carbon atom has to join to three other things (2 hydrogen atoms and another carbon atom). It reorganises 3 of its s and p electrons into 3 orbitals with the same shape and energy. These are called sp^2 hybrids. The other p orbital is left unchanged.



The sp^2 hybrids arrange themselves as far apart as possible with the remaining p orbital at right angles to them.



d) The hybrid orbitals overlap in space with the $1s^1$ orbital on two hydrogen atom and with one of the sp^2 orbitals on the other carbon atom to form molecular orbitals containing both electrons. These are known as sigma bonds.



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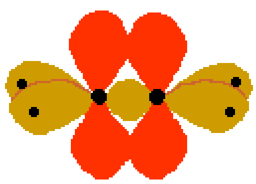
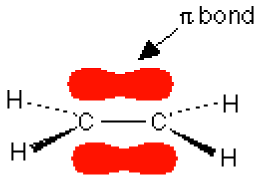


The remaining p orbitals overlap sideways to give a pi bond, above and below the plane of the rest of the molecule.



(Remember that bonds shown as dotted lines are going into the paper or screen away from you. The ones shown as wedges are coming out towards you.)

2. a) The bond angles are 120° because the sp^2 orbitals got as far apart as possible from each other – which is in a plane at 120° to each other. The molecule is planar (***all*** the atoms are in one plane) because of the need to have the p orbitals parallel to each other in order to overlap sideways.

   b) Any rotation about the carbon-carbon bond would mean you have to break the pi bond, because the p orbitals wouldn't be parallel to each other any more. Breaking any bond costs energy, and enough energy to break the pi bond is only achieved at high temperatures.