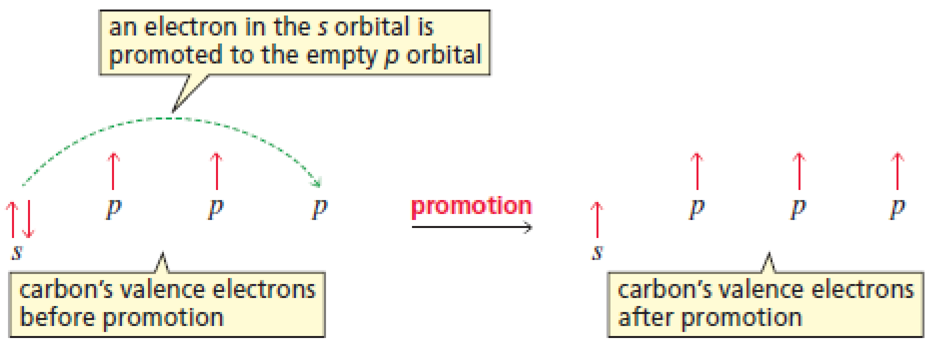
Hybridization of Atomic orbital

تهجين الاوربيتلات الذرية

- **Hybridization**: *The concept of combining atomic orbitals.*
- التهجين : هو مبداء دمج الاوربيتالات الذرية.
- **Hybrid orbitals:** *are mixed orbitals that result from combining atomic orbitals.*
- الاوربيتلات الهجينة : هي مدارات مختلطة ناتجة عن عملية دمج الاوربيتلات الذرية.

1. *sp^3 Hybridization:*

Consider the CH_4 molecule. If one of the electrons in carbon's 2 *s* orbital were promoted into its empty 2 *p* orbital, then carbon would have four unpaired valence electrons (in which case four covalent bonds could be formed).



عند اخذ جزيئة CH4 كمثال اذا افترضنا ان الكترون انتقل من الاوربيتال 2s الى الاوربيتال الفارغ 2p فان ذرة الكاربون سوف تمتلك اربع الكترونات منفردة و بذلك يمكن ان تكون اربع اواصر.

However, we have seen that the four C- H bonds in methane are identical. How can they be identical if carbon uses an *s* orbital and three *p* orbitals to form these four bonds? Wouldn't the bond formed with the *s* orbital be different from the threebonds formed with *p* orbitals? The four C-H bonds are identical because carbon uses hybrid atomic orbitals.

لكن اوصر C-H الاربعة هي متطابقة و حسب التفسير السابق هذا لايجوز حيث ان الاواصر الناتجة عن ارتباط الاوربتال s تختلف عن الاواصر الناتجة عن ارتباط الاوربيتال p. مما يقود الى الاستنتاج اواصر C-H الاربعة متطابقة لان ذرة الكاربون استخدمت اوربيتالات هجينة في هذه الاواصر.

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If the one *s* and three *p* orbitals of the second shell are all combined and then apportioned into four equal orbitals, each of the four resulting orbitals will be one part *s* and three parts *p* . This type of mixed orbital is called an sp^3 orbital.

اذا اندمجت اوربيتالات الغلاف الثاني واحد من نوع s مع ثلاث من نوع p سوف ينتج تكوين اربع اوربيتالات متساوية كل منها متكون من جزء s وثلاث اجزاء p . هذا النوع من الاوربيتلات الهجينة يعرف باوربيتال هجين نوع sp3.

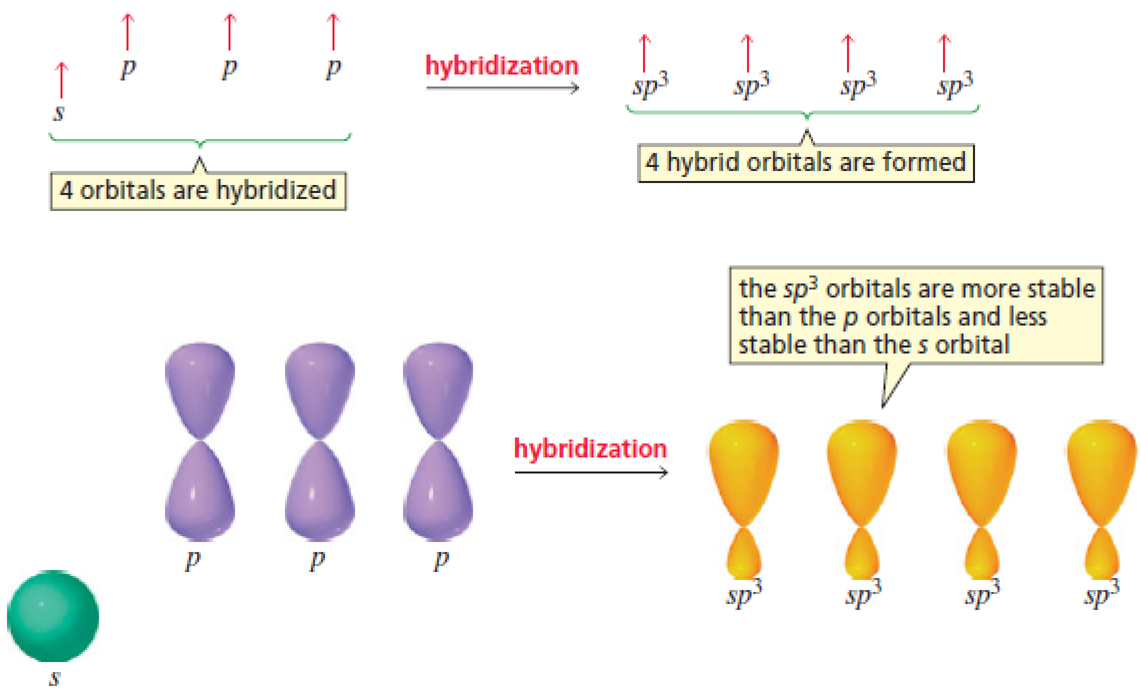


Figure 1.1 *An s orbital and three p orbitals hybridize to form four sp^3 orbitals. An sp^3 orbital is more stable (lower in energy) than a p orbital, but less stable (higher in energy) than an s orbital.*

The four sp^3 orbitals adopt a spatial arrangement that keeps them as far away from each other as possible. They do this because electrons repel each other, and moving as far from each other as possible minimizes the repulsion. When four sp^3 orbitals move as far from each other as possible, they point toward the corners of a regular tetrahedron—a pyramid with four faces, each an equilateral triangle (Figure 1.2a). Each of the four C-H bonds in methane is formed from the overlap of an sp^3 orbital of carbon with the *s* orbital of a hydrogen (Figure 1.2b). This explains why the four C-H bonds are identical.

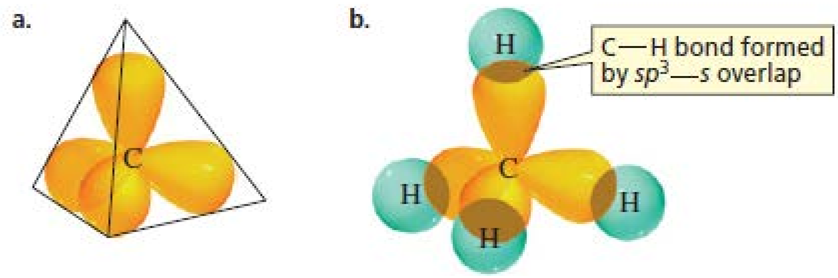
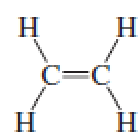


Figure 1.2 ***a.*** *The four sp* ^{3} *orbitals are directed toward the corners of a tetrahedron, causing each bond angle to be 109.5*؛*.This arrangement allows the four orbitals to be as far apart as possible.* ***b.*** *An orbital picture of methane, showing the overlap of each sp* ^{3}*orbital of carbon with the s orbital of a hydrogen. (For clarity, the smaller lobes of the sp* ^{3} *orbitals are not shown.)*

2. *sp2 Hybridization*

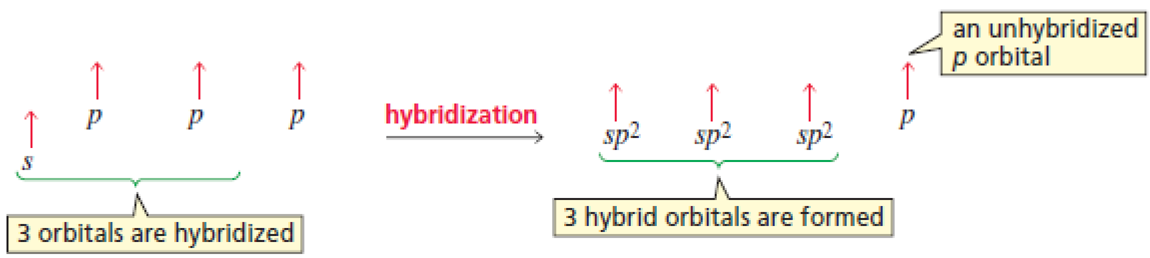
Each of the carbon atoms in ethene (also called ethylene) forms four bonds, but each carbon is bonded to only three atoms:



ان كلتا ذرتي الكاربون الموجودتين في جزيئة الايثين تكون اربع اواصر ، لكن كل ذرة مرتبطة مع ثلاث ذرات فقط.

To bond to three atoms, each carbon hybridizes three atomic orbitals: an s orbital and two of the p orbitals. Because three orbitals are hybridized, three hybrid orbitals are formed. These are called *sp* ^{2} orbitals. After hybridization, each carbon atom has three degenerate *sp* ^{2} orbitals and one un-hybridized *p* orbital:

لربط هذة الجزيئات الثلاثة ، كل ذرة كاربون سوف تقوم بتهجين ثلاث اوربيتالات اوربتال واحد نوع s و اوربتالين نوع p حيث سوف تتكون ثلاث اوربتالات هجينة لكل ذرة كاربون. هذه الاوربتلات تعرف بالاوربتلات الهجينة نوع sp2. بعد عملية التهجين كلتا ذرتي الكاربون سوف تملك ثلاث اوربتلات هجينة نوع sp2 و اوربتال غير هجين نوع p.



To minimize electron repulsion, the three *sp* 2 orbitals need to get as far from each other as possible. Therefore, the axes of the three orbitals lie in a plane, directed toward the corners of an equilateral triangle with the carbon nucleus at the center. As a result, the bond angles are all close to 120° (Figure 1.3a).

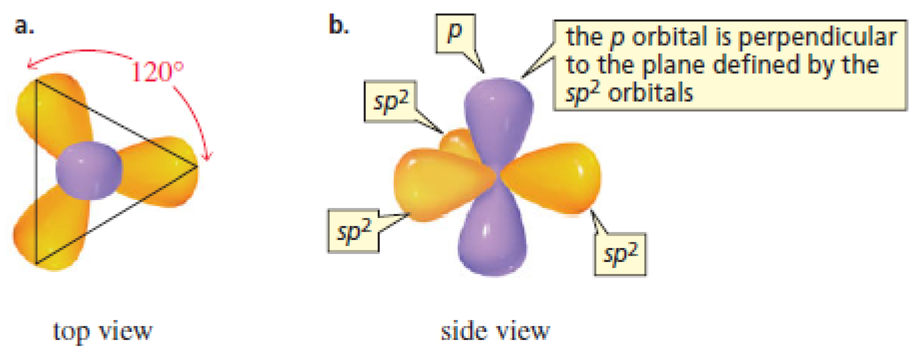


Figure 1.3 ***a.*** *The three degenerate sp 2 orbitals lie in a plane, oriented 120° from each other. (The smaller lobes of the sp ^{2} orbitals are not shown.)* ***b.*** *The unhybridized p orbital is perpendicular to this plane.*

Because an sp ^{2} carbon is bonded to three atoms that define a plane, it is called a **trigonal planar carbon**. The unhybridized p orbital is perpendicular to the plane defined by the axes of the sp ^{2} orbitals (Figure 1.3b).

The carbons in ethene form two bonds with each other. Two bonds connecting two atoms are called a **double bond.** The two carbon–carbon bonds in the double bond are not identical. One of them results from the overlap of an sp^2 orbital of one carbon with an sp^2 orbital of the other carbon; this is a sigma (σ) bond because it is cylindrically symmetrical (Figure 1.4a). The second carbon–carbon bond results from side-to-side overlap of the two unhybridized *p* orbitals. Side-to-side overlap of *p* orbitals forms a pi (π) bond (Figure 1.4b). Thus, one of the bonds in a double bond is a σ bond, and the other is a π bond. All the C-H bonds are σ bonds. (Remember that all single bonds in organic compounds are σ bonds.)

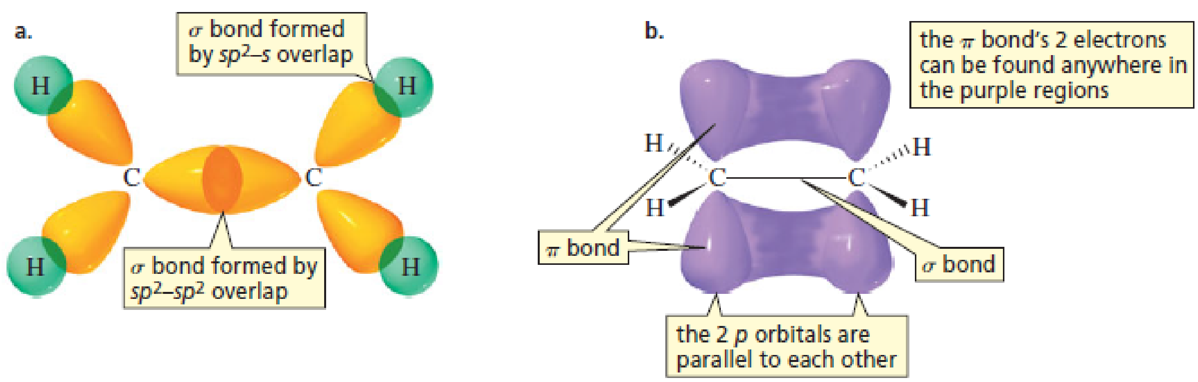


Figure 1.4 ***a.*** *One C—C bond in ethene is a σ bond formed by sp 2 – sp 2 overlap, and the C—H bonds are σ bondsformed by sp 2 – s overlap.* ***b.*** *The second C—C bond is a π bond formed by side-to-side overlap of a p orbital of one carbon with a p orbital of the other carbon. The two p orbitals are parallel to each other.*

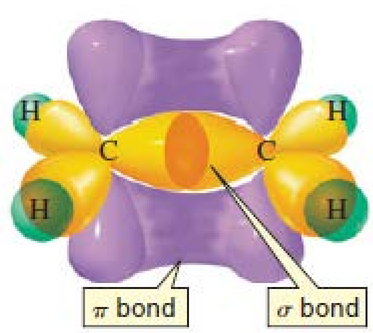
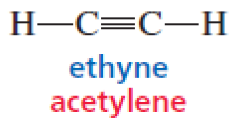


Figure 1.5 *The two carbons and four hydrogens lie in the same plane. Perpendicular to that plane are the two parallel p orbitals. This results in an accumulation of electron density above and below the plane containing the two carbons and four hydrogens.*

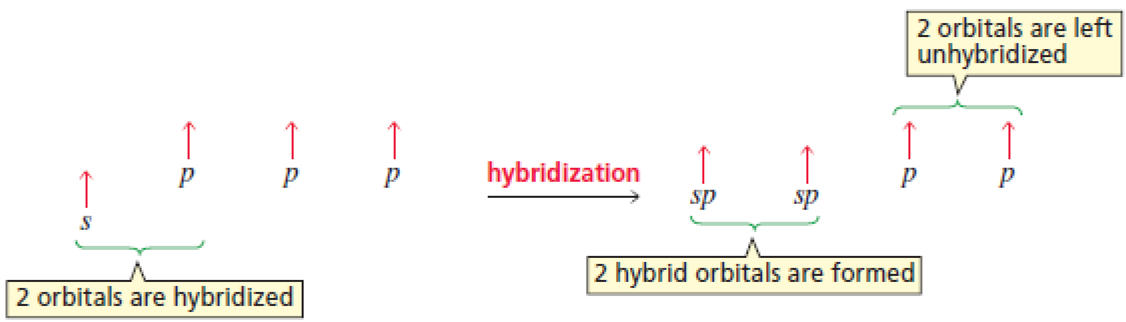
3. *sp Hybridization*

Each of the carbon atoms in ethyne (also called acetylene) forms four bonds, but each carbon is bonded to only two atoms—a hydrogen and another carbon:



كلتا ذرتي الكاربون في جزيئة الاثيلين تمتلك اربع اواصر، لكن كل ذرة كاربون ترتبط بذرتين فقط.

In order to bond to two atoms, each carbon hybridizes two atomic orbitals—an *s* and a *p* .Two degenerate *sp* orbitals result. Each carbon atom in ethyne, therefore, has two *sp* orbitals and two unhybridized *p* orbitals.



لربط هذه الذرتين، كلتا ذرتي الكاربون سوف تقوم بتهجين اوربتالين ذريين احدهما من نوع s و الاخر من نوع p . و بذلك سوف ينتج اوربتالين هجينين نوع sp. لذلك فان ذرتي الكاربون في جزيئة الاثلين تمتلك اوربتالين هجينين نوع sp و اوربتالين غير هيجنين نوع p.

To minimize electron repulsion, the two *sp* orbitals point in opposite directions. The two unhybridized *p* orbitals are perpendicular to each other and are perpendicular to the *sp* orbitals (Figure 1.6). The two carbons in ethyne are held together by three bonds. Three bonds connecting two atoms are called a **triple bond.** One of the *sp* orbitals of one carbon in ethyne overlaps an *sp* orbital of the other carbon to form a carbon–carbon s bond. The other *sp* orbital of each carbon overlaps the s orbital of a hydrogen to form a C-H σ bond (Figure 1.7a). Because the two *sp* orbitals point in opposite directions, the bond angles are 180°. Each of the unhybridized p orbitals engages in side-to-side overlap with a parallel *p* orbital on the other carbon, resulting in the formation of two π bonds (Figure 1.7b).

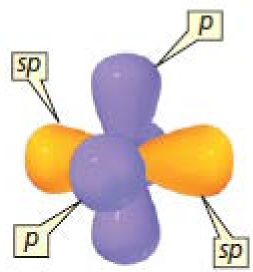


Figure 1.6 *The two sp orbitals point in opposite directions. The two unhybridized p orbitals are perpendicular to each other and to the sp orbitals. (The smaller lobes of the sp orbitals are not shown.)*

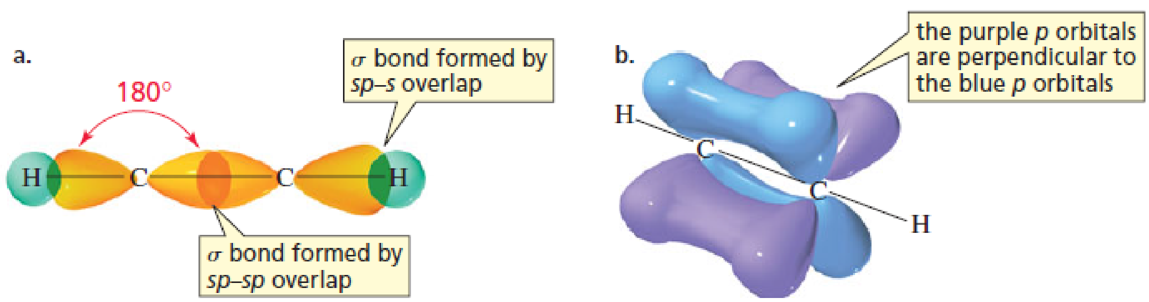


Figure 1.7 a. *The C—C σ bond in ethyne is formed by sp – sp overlap, and the C—H bonds are formed by sp – s overlap. The carbon atoms and the atoms bonded to them form a straight line.* ***b.*** *The two carbon–carbon π bonds are formed by side-to-side overlap of the two p orbitals of one carbon with the two p orbitals of the other carbon.*