

13.3 Shapes of organic molecules; sigma and pi bonds

Name: _____ Class: _____ Date: _____

Total: 12 marks

KEY WORDS planar 平面 • cyclic 环状 • hybridisation 杂化 • pi bond π 键

Objective

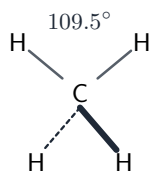
Build the skills to answer exam questions on **shapes of organic molecules** — **hybridisation** 杂化 (sp , sp^2 , sp^3), σ and π **bonds**, and the term **planar** 平面.

You must be able to:

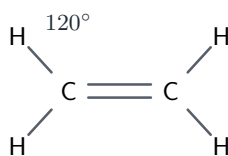
- describe organic molecules as straight-chained, branched or cyclic
- describe and explain the shape and bond angles at sp , sp^2 and sp^3 carbons
- describe the arrangement of σ and π bonds

1 Worked examples

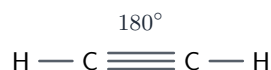
■ Hybridisation and shape



sp^3 : 4 single bonds
tetrahedral

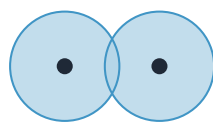


sp^2 : 1 double + 2 single
planar (flat)

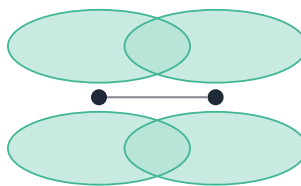


sp : 1 triple bond
linear

$sp^3 = \text{tetrahedral } (109.5^\circ)$; $sp^2 = \text{planar } (120^\circ)$; $sp = \text{linear } (180^\circ)$



σ bond:
head-on overlap



π bond: sideways overlap
of p orbitals

Hybridisation builds sigma and pi bonds

hybridisation	bonds	shape	angle
sp^3	4 single	tetrahedral	109.5°
sp^2	1 double + 2 single	planar	120°
sp	1 triple	linear	180°

Every single bond is a σ **bond** (direct overlap); a double bond is one σ + one π **bond** (sideways p-orbital overlap). Ethene is **planar** because its carbons are sp^2 .

2 Practice

2.1 State the shape and bond angle around an sp^3 carbon. [2]

2.2 State how many σ and π bonds make up a $C=C$ double bond. [2]

3 Exam-style questions

3.1 The carbon atoms in ethene, C_2H_4 , are: [1]

- A sp hybridised, linear
- B sp^2 hybridised, planar
- C sp^3 hybridised, tetrahedral
- D sp^3 hybridised, planar

3.2 The bond angle around the carbon in methane is: [1]

- A 90°
- B 104.5°
- C 109.5°

- D 120°

3.3 (a) State the shape and bond angle around each carbon in ethyne, C_2H_2 . [2]

(b) Explain why ethene is a planar molecule. [2]

3.4 Describe the σ and π bonds present in a molecule of ethene, C_2H_4 . [2]

Solutions

2.1 tetrahedral; 109.5° .

2.2 1 σ bond and 1 π bond.

3.1 B. Ethene's carbons are sp^2 hybridised and the molecule is planar.

3.2 C. Methane's bond angle is 109.5° .

3.3 (a) linear; 180° .

(b) the carbons are sp^2 hybridised with 120° bond angles; all the atoms lie in one plane around the $\text{C}=\text{C}$ double bond, so it is planar.

3.4 five σ bonds (4 $\text{C}-\text{H}$ and 1 $\text{C}-\text{C}$) formed by direct overlap; one π bond from sideways overlap of p orbitals above and below the $\text{C}=\text{C}$.