A-LEVEL CHEMISTRY • EXERCISE SHEET

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

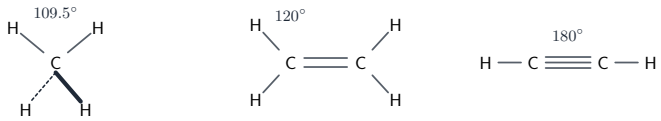
Build the skills to answer exam questions on **shapes of organic molecules** — **hybridisation** 杂化 (sp, sp^2, sp^3), **σ and π bonds**, and the term **planar** 平面.

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

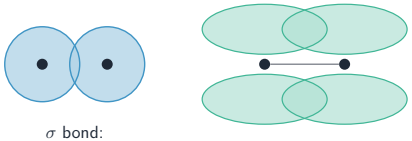


sp^3: 4 single bonds tetrahedral

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

sp: 1 triple bond linear

sp^3 = tetrahedral (109.5°); sp^2 = planar (120°); sp = linear (180°)



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 C=C double bond, so it is planar.

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