▶ Video explanation (YouTube Short)

Structure and Polarity of the Carbonyl Group

The carbon of the **carbonyl group, C=O**, is the site every nucleophile attacks. Its structure and its polarity explain why.

1. sp² carbon, planar group (NCERT 8.1.2)

- The carbonyl carbon is **sp² hybridised** and forms **three σ bonds**.
- The carbon and the three atoms attached to it lie in **one plane**: the group is **trigonal planar**, with bond angles of about **120°**.

2. The π bond

Carbon's fourth electron is in an unhybridised **p orbital**. It overlaps sideways with a p orbital of oxygen to form the **π bond**. The π electron cloud lies **above and below** the plane. Oxygen also carries **two lone pairs**.

3. Polarity

Atom	Partial charge	Behaviour
Oxygen (more electronegative)	δ^-	nucleophilic (Lewis base)
Carbon	δ^+	electrophilic (Lewis acid)

The bonding electrons are pulled towards oxygen, so carbonyl compounds have substantial dipole moments and are **more polar than ethers**.

4. Resonance

The polarity is explained by resonance between the neutral structure and a dipolar one: $\mathbf{R_2C{=}O \leftrightarrow R_2C^+{-}O^-}$ (the π electrons move onto oxygen). The real molecule is a **hybrid** of the two.

Solved example

Q. Why does a nucleophile attack the carbon and not the oxygen of a carbonyl group?
A. Oxygen is more electronegative, so the C=O electrons are pulled towards it: carbon is δ^+ (electron-poor, electrophilic) and oxygen is δ^-. An electron-rich nucleophile is attracted to the δ^+ carbon. The dipolar resonance structure, $C^+–O^-$, shows the same thing.

Key takeaways

- sp² carbon, three σ bonds, planar, about 120°.
- π bond from sideways p–p overlap; π cloud above and below the plane.
- C=O is polar: C δ^+ (electrophilic), O δ^- (nucleophilic); more polar than ethers.
- Resonance hybrid of C=O and $C^+–O^-$; nucleophiles attack the carbon.

Practice questions

1. (MCQ) The hybridisation of the carbonyl carbon is: (a) sp (b) sp^2 (c) sp^3 (d) dsp^2
2. (MCQ) The bond angles around the carbonyl carbon are about: (a) 90° (b) 109.5° (c) 120° (d) 180°
3. (MCQ) In C=O, the partial positive charge is on: (a) oxygen (b) carbon (c) both (d) neither
4. (Very short) How many lone pairs does the carbonyl oxygen carry?
5. (Very short) Where does the π electron cloud of C=O lie?
6. (Short) Why are carbonyl compounds more polar than ethers?
7. (Short) Write the two resonance structures of the carbonyl group.
8. (Application) Explain why the carbonyl carbon behaves as a Lewis acid and the oxygen as a Lewis base.

Answer key

1. (b) sp^2.
2. (c) 120°.
3. (b) carbon.
4. Two.
5. Above and below the plane of the carbonyl group.
6. The C=O bond is strongly polarised (O much more electronegative, plus the dipolar resonance structure $C^+–O^-$), giving a large dipole moment.
7. $R_2C{=}O \longleftrightarrow R_2C^+–O^-$.
8. The δ^+ carbon is electron-poor and accepts an electron pair (Lewis acid); the δ^- oxygen, with two lone pairs, can donate an electron pair (Lewis base).

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