

Lewis structures, shapes and hybridization of molecules

AP Chemistry · Test answers (mark scheme)

Marks reward correct electron counting, the right domain count and clear reasoning about polarity. Accept equivalent wording or a correctly drawn structure instead of a description.

Level: AP Chemistry · **Curriculum:** AP Chem Unit 2

Question 1 Lewis structure of PCl_3 (3 marks)

- a. P in the centre with three single bonds to Cl, each Cl with three lone pairs, and one lone pair on P.
- b. **Trigonal pyramidal**, about 100° to 107° .
- c. Four domains: **sp^3** .

Marking: 1 mark each part.

Question 2 Formal charges in carbon monoxide (3 marks)

- a. C: $4 - 2 - 3 = -1$.
- b. O: $6 - 2 - 3 = +1$.
- c. Both atoms have an octet, which is more important, and the triple bond gives a very strong bond. The formal charges are small.

Marking: 1 mark each part.

Question 3 Resonance in carbonate (2 marks)

- a. **Three**.
- b. $(2 + 1 + 1)/3 = 1.33$.

Marking: 1 mark each part.

Question 4 Sulfur tetrafluoride (3 marks)

- a. Four bonds use 8 electrons, the F atoms have 24, so 2 remain: **one lone pair**.
- b. Five domains: electron geometry **trigonal bipyramidal**, molecular shape **seesaw**.
- c. **Polar**: the lone pair makes the shape asymmetric, so the dipoles do not cancel.

Marking: 1 mark each part.

Question 5 Methanal (3 marks)

- a. 2 C-H σ , 1 C=O σ and 1 π : **3 σ and 1 π** .
- b. Three domains: **sp^2** .
- c. Slightly less than 120° , because the double bond region has more electron density and repels the C-H bonds more.

Marking: 1 mark each part.

Question 6 Polarity of CF₄ and CHF₃ (2 marks)

CF₄ is tetrahedral and the four identical C-F dipoles cancel, so it is **nonpolar**. In CHF₃ one F is replaced by H, so the dipoles are unequal and do not cancel; the molecule is **polar**.

Marking: 1 mark for symmetry cancellation; 1 mark for the asymmetry of CHF₃.

Question 7 Bond strength (2 marks)

- a. The **C=O** bond in methanal.
- b. The double bond shares more electron pairs, so the nuclei are pulled closer together.

Marking: 1 mark each part.

Question 8 Spot the error (2 marks)

Nitrogen has a lone pair as well as three bonds, so it has four domains and tetrahedral electron geometry. The molecule is **trigonal pyramidal with an angle of about 107°** .

Marking: 1 mark for noting the lone pair; 1 mark for the shape and angle.