

Lewis structures, shapes and hybridization of molecules

AP Chemistry · Worksheet

Name: _____ Date: _____ Class: _____

These 20 problems cover bond types, Lewis structures, formal charge, resonance, VSEPR shapes, polarity and hybridization. They follow the style of AP Chemistry unit 2.

The first problems build routine skills such as counting valence electrons. Later problems combine several ideas, including expanded octets, resonance and the link between bond order, length and energy.

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

Problem 1 Classify the bonds (easy)

Electronegativities: H 2.20, Na 0.93, Cl 3.16, F 3.98, C 2.55.

1. Calculate the electronegativity difference for NaCl, HCl and Cl₂.
2. Classify each bond as ionic, polar covalent or nonpolar covalent.
3. Show the partial charges on HCl.

Problem 2 Count valence electrons (easy)

Aarav in Pune is drawing Lewis structures.

1. Find the total valence electrons for H₂O.
2. Find the total for CO₂.
3. Find the total for NH₄⁺.
4. Find the total for NO₃⁻.

Problem 3 Simple Lewis structures (easy)

Draw the Lewis structure for each molecule and show lone pairs.

1. CH₄
2. HCN (H bonded to C, C bonded to N)
3. State the number of lone pairs on N in HCN.

Problem 4 Formal charges on ions (easy)

Use formal charge = valence – nonbonding – $\frac{1}{2}$ bonding.

1. Calculate the formal charge on N in NH₄⁺ (four N-H bonds, no lone pairs).
2. Calculate the formal charge on O in OH⁻ (one bond, three lone pairs).

Problem 5 Water's shape (easy)

Consider H_2O .

1. State the number of electron domains on oxygen.
2. Name the electron geometry and the molecular shape.
3. Give the approximate H-O-H angle.

Problem 6 Bond length and energy (easy)

Data: C-C 154 pm, 347 kJ/mol; C=C 134 pm, 614 kJ/mol; C≡C 120 pm, 839 kJ/mol.

1. State the trend in bond length as bond order rises.
2. State the trend in bond energy.
3. Explain both trends.

Problem 7 Direction of polarity (easy)

Use the electronegativities above and O 3.44.

1. State which atom is δ^- in H-F.
2. State which atom is δ^- in C-O.
3. Draw a dipole arrow for each bond.

Problem 8 Nitrate and resonance (medium)

The nitrate ion, NO_3^- , has 24 valence electrons.

1. Draw one Lewis structure and calculate each formal charge.
2. State the number of resonance structures.
3. Calculate the average N-O bond order.

Problem 9 Choosing the best structure (medium)

Three possible structures for thiocyanate, SCN^- , are $\text{S}-\text{C}\equiv\text{N}$, $\text{S}=\text{C}=\text{N}$ and $\text{S}\equiv\text{C}-\text{N}$.

Electronegativities are S 2.58, C 2.55, N 3.04.

1. Calculate the formal charges on S, C and N in each structure.
2. Identify the least favourable structure and explain.
3. State which of the other two is better and why.

Problem 10 Expanded octet in SF_6 (medium)

Sulfur hexafluoride has 48 valence electrons.

1. Draw the Lewis structure.
2. State how many electrons surround S.
3. Name the molecular shape and give the F-S-F angle.

Problem 11 Predict the shape (medium)

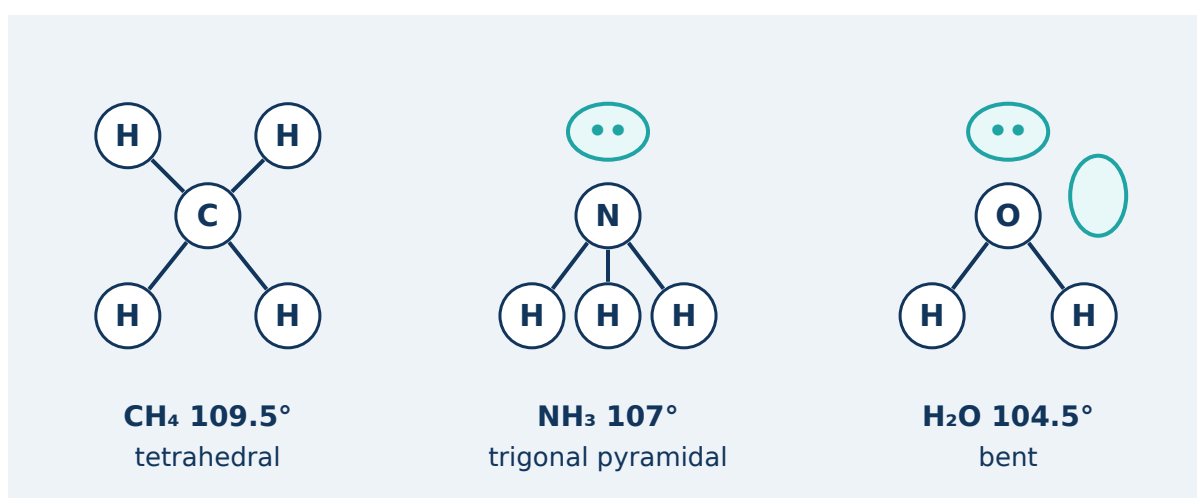
For each species give the electron geometry, the molecular shape and the hybridization of the central atom.

1. BF_3
2. SO_2 (18 valence electrons)
3. CH_4

Problem 12 Why do angles differ? (medium)

The bond angles are CH_4 109.5° , NH_3 107° and H_2O 104.5° .

1. State the number of lone pairs on each central atom.
2. Explain the trend in bond angles.



Three molecules with tetrahedral electron geometry.

Problem 13 Is the molecule polar? (medium)

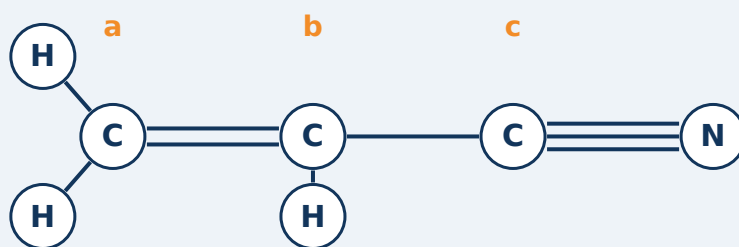
Decide whether each molecule is polar and explain.

1. CO_2 (linear)
2. SO_2 (bent)
3. CCl_4 (tetrahedral)
4. CHCl_3 (tetrahedral)

Problem 14 Sigma and pi bonds in acrylonitrile (medium)

The figure shows acrylonitrile.

1. Count the σ bonds.
2. Count the π bonds.
3. State the hybridization of carbons a, b and c.



Acrylonitrile: C_3H_3N with carbons labelled a, b and c.

Problem 15 Ozone (medium)

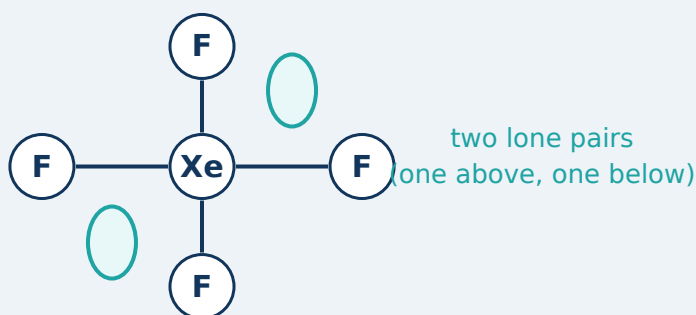
Ozone, O_3 , has 18 valence electrons and a central oxygen atom.

1. Draw two resonance structures.
2. Calculate the formal charges on each oxygen.
3. State the bond order and the approximate bond angle.

Problem 16 Xenon tetrafluoride (hard)

XeF_4 has 36 valence electrons. The figure shows the structure.

1. Show that the Lewis structure has two lone pairs on xenon.
2. State the electron geometry and molecular shape.
3. State the hybridization and explain why the molecule is nonpolar.



XeF_4 drawn as a flat square. The lone pairs sit above and below the plane.

Problem 17 Bond order in the nitrogen family (hard)

$N-N$ is 145 pm and 160 kJ/mol; $N=N$ is 125 pm and 418 kJ/mol; $N\equiv N$ is 110 pm and 945 kJ/mol.

1. Calculate how many times stronger the triple bond is than the single bond.
2. Explain the length trend in terms of shared electrons and the attraction between nuclei.
3. Suggest why N_2 gas is chemically unreactive.

Problem 18 Dinitrogen monoxide (hard)

N_2O has the atom order N-N-O and 16 valence electrons.

1. Draw two resonance structures.
2. Calculate the formal charges on each atom in both.
3. State which structure contributes more and give the molecular shape.

Problem 19 Chlorine trifluoride (hard)

ClF_3 has 28 valence electrons.

1. Draw the Lewis structure and state the number of lone pairs on Cl.
2. Name the electron geometry and the molecular shape.
3. State the hybridization and explain whether the molecule is polar.

Problem 20 Nitrogen dioxide ions (hard)

Compare NO_2^+ (16 valence electrons) and NO_2^- (18 valence electrons), with N as the central atom.

1. Draw a Lewis structure for each ion.
2. Predict the shape, the angle and the hybridization of each.
3. Explain why the angles differ.