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Unit 2: Molecular & Ionic Compounds

Accessible Practice Set - Building Foundations

✓ Easier Level | ⏱ 60-90 minutes | 📊 10 Questions

📋 About This Practice Set:

- **Purpose:** Build confidence with foundational Unit 2 bonding concepts
- **Difficulty:** Easier than typical AP exam (scaffolded with visual support)
- **Focus Areas:** Lewis structures, VSEPR theory, molecular geometry, polarity, hybridization
- **Question Types:** Drawing structures, predicting shapes, determining polarity
- **Total Points:** 65 points (partial credit opportunities)
- **Materials Needed:** Periodic table, electronegativity chart (provided below)

📊 Electronegativity Values (Pauling Scale)

Element	EN	Element	EN	Element	EN	Element	EN
H	2.1	C	2.5	N	3.0	O	3.5
F	4.0	Cl	3.0	Br	2.8	S	2.5

Bond Polarity Guide: ΔEN < 0.4 = nonpolar covalent; 0.4 ≤ ΔEN < 1.7 = polar covalent; ΔEN ≥ 1.7 = ionic

💡 Success Tips for Unit 2:

- **Lewis Structures:** Count all valence electrons first! (Group # for main group elements)
- **Octet Rule:** Most atoms want 8 valence electrons (H wants 2, B can have 6)
- **VSEPR Theory:** Electron domains (bonds + lone pairs) determine geometry
- **Bond Angles:** Linear = 180°; Trigonal planar = 120°; Tetrahedral = 109.5°; Bent/Trigonal pyramidal are less
- **Molecular Polarity:** Polar bonds + asymmetric shape = polar molecule
- **Common Mistakes:** Don't forget lone pairs! They affect shape but aren't "seen" in molecular geometry name

VSEPR Geometry Quick Reference

Electron Domains	Electron Geometry	Example (if 0 lone pairs)	Bond Angle
2	Linear	CO_2	180°
3	Trigonal Planar	BF_3	120°
4	Tetrahedral	CH_4	109.5°

Note: Lone pairs count as electron domains but molecular geometry name only describes atom positions!

Question 1 (6 points) — Lewis Structures: Simple Molecules

Draw Lewis structures for the following molecules. Show all bonds (as lines) and all lone pairs (as dots).

> **Valence Electrons:** H = 1, C = 4, N = 5, O = 6, F = 7, Cl = 7

(a) Water (H_2O) — Central atom: O (2 points)

Steps:

1. Count total valence electrons: H(1×2) + O(6) = 8 electrons
2. Connect atoms with single bonds: H—O—H uses 4 electrons
3. Complete octets: Add remaining 4 electrons as lone

pairs on O

Draw your Lewis structure here:

(b) Ammonia (NH_3) — Central atom: N (2 points)

Hint:

Total valence electrons = N(5) + H(1×3) = 8 electrons

Draw your Lewis structure here:

(c) Methane (CH_4) — Central atom: C (2 points)

Draw your Lewis structure here:

Question 2 (7 points) — VSEPR Theory and Molecular Geometry

For each molecule from Question 1, determine the molecular geometry.

Common Molecular Geometries

Blue = central atom; Red = bonded atoms; Orange = lone pairs (electron domains)

(a) For H_2O: Count the electron domains around oxygen (bonding pairs + lone pairs). What is the electron geometry? What is the molecular geometry? (3 points)

Remember:

Electron geometry considers ALL electron domains. Molecular geometry describes only atom positions.

Your answer:

(b) For NH_3: Count electron domains. Determine electron geometry and molecular geometry. (2 points)

Your answer:

(c) For CH_4: Determine the molecular geometry and predict the bond angle. (2 points)

Your answer:

Question 3 (6 points) — Bond Polarity and Electronegativity

Use the electronegativity values provided in the reference table to answer these questions.

(a) Calculate the electronegativity difference (ΔEN) for the following bonds: (3 points)

Bond	ΔEN Calculation	ΔEN Value
H—O		
C—H		

N—H		

Formula:

$\Delta EN = |EN(\text{more electronegative}) - EN(\text{less electronegative})|$

(b) Classify each bond as nonpolar covalent, polar covalent, or ionic. (2 points)

Your classifications:

(c) Which bond is most polar? Explain your reasoning. (1 point)

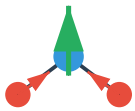
Your answer:

Question 4 (7 points) — Molecular Polarity

Determine whether each molecule is polar or nonpolar.

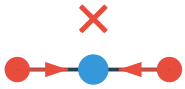
Understanding Molecular Polarity

POLAR (H_2O)



Asymmetric → Net dipole

NONPOLAR (CO_2)



Symmetric → Dipoles cancel

(a) Is H_2O polar or nonpolar? Explain using both bond polarity and molecular shape. (2 points)

Your answer:

(b) Is CH_4 polar or nonpolar? Explain. (2 points)

Hint:

CH_4 is tetrahedral (symmetrical). Do the C—H bond dipoles cancel?

Your answer:

(c) Is NH_3 polar or nonpolar? Explain. (2 points)

Your answer:

(d) What makes a molecule polar overall? (1 point)

Your answer:

Question 5 (6 points) — Lewis Structures with Multiple Bonds

Draw Lewis structures for molecules containing double or triple bonds.

(a) Carbon dioxide (CO_2) — Central atom: C (3 points)

Steps:

1. Total valence electrons: C(4) + O(6×2) = 16 electrons
2. Connect: O—C—O uses 4 electrons

3. Complete octets on oxygens: needs 12 more electrons (6 per O)
4. C only has 4 electrons! Must form double bonds: O=C=O

Draw Lewis structure with all lone pairs:

(b) What is the molecular geometry of CO_2? Is it polar or nonpolar? (2 points)

Your answer:

(c) Nitrogen gas (N_2) has a triple bond. Draw its Lewis structure. (1 point)

Draw Lewis structure:

Question 6 (7 points) — Resonance Structures

The carbonate ion (CO_3^{2-}) has three equivalent resonance structures.

Given:

- Total valence electrons: C(4) + O(6×3) + 2 extra electrons (from 2− charge) = 24 electrons
- Carbon is the central atom

(a) Draw ONE resonance structure for CO_3^{2-}. Show all bonds and lone pairs. (3 points)

Hint:

One C=O double bond and two C—O single bonds. Don't forget the 2− charge!

Draw one resonance structure:

(b) How many resonance structures does CO_3^{2-} have total? (1 point)

Your answer:

(c) What is the molecular geometry of CO_3^{2-}? (1 point)

Hint:

Count electron domains around C (ignore the charge location)

Your answer:

(d) Explain what resonance means. Do the electrons actually "move" between structures? (2 points)

Your explanation:

Question 7 (6 points) — Hybridization Introduction

Determine the hybridization of the central atom in each molecule.

Hybridization Quick Guide

Electron Domains	Hybridization	Geometry	Example
2	sp	Linear	CO_2
3	sp^2	Trigonal Planar	BF_3
4	sp^3	Tetrahedral	CH_4, NH_3, H_2O

(a) What is the hybridization of carbon in CH_4? (2 points)

Hint:

Count electron domains around C

Your answer:

(b) What is the hybridization of carbon in CO_2? (2

points)

Your answer:

(c) What is the hybridization of nitrogen in NH_3? (2 points)

Your answer:

Question 8 (6 points) — Comparing Bond Lengths and Strengths

Consider the following carbon-carbon bonds:

Bond Types:
- Single bond: C—C
- Double bond: C=C
- Triple bond: C≡C

(a) Rank these bonds in order of increasing bond length (shortest to longest). (2 points)

Your ranking:

(b) Rank these bonds in order of increasing bond strength (weakest to strongest). (2 points)

Your ranking:

(c) Explain the relationship between bond order, bond length, and bond strength. (2 points)

Your explanation:

Question 9 (7 points) — Ionic vs. Covalent Bonding

Classify the following compounds and explain the bonding.

(a) Classify each compound as primarily ionic or covalent: (3 points)

Compound	Ionic or Covalent?
NaCl	
H_2O	
MgO	

(b) Explain how you determine whether a compound is ionic or covalent. (2 points)

Hint:

Think about metal vs. nonmetal and electronegativity difference

Your explanation:

(c) What is the main difference between ionic and covalent bonding? (2 points)

Your answer:

Question 10 (7 points) — Conceptual Understanding

(a) Why does water have a bent shape rather than linear? Explain using VSEPR theory. (2 points)

Your explanation:

(b) Why is CO_2 nonpolar even though it has polar C=O bonds? (2 points)

Your explanation:

(c) Explain why lone pairs take up more space than bonding pairs. (2 points)

Hint:

Think about electron distribution and repulsion

Your explanation:

(d) True or False: A molecule with polar bonds must be polar overall. Explain. (1 point)

Your answer:

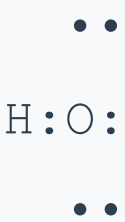
END OF PRACTICE SET

Review your Lewis structures and geometries before checking answers!

✅ ANSWER KEY & DETAILED SOLUTIONS

Question 1: Lewis Structures - Complete Solutions (6 points)

(a) H_2O (2 points)



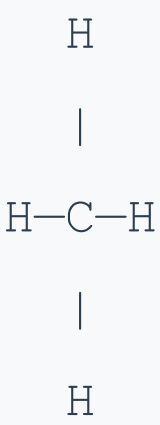
Or with lines: H—O—H (with 2 lone pairs on O)
Total: 2 O—H bonds + 2 lone pairs on O = 8 electrons total

Scoring: 1 pt for correct bonds; 1 pt for correct lone pairs

(b) NH_3 (2 points)

Or: H—N—H with one H below, and 1 lone pair on N

(c) CH_4 (2 points)



No lone pairs on carbon (all 8 electrons in bonds)

Questions 2-10: Answer Summary

Q2 (VSEPR): (a) H_2O: 4 electron domains (2 bonds + 2 lone pairs); Electron geometry = tetrahedral; Molecular geometry = bent; (b) NH_3: 4 domains (3 bonds + 1 lone pair); Electron = tetrahedral; Molecular = trigonal pyramidal; (c) CH_4: tetrahedral; 109.5° bond angles

Q3 (Bond Polarity): (a) H—O: |3.5−2.1| = 1.4; C—H: |2.5−2.1| = 0.4; N—H: |3.0−2.1| = 0.9; (b) H—O = polar covalent; C—H = polar covalent (barely); N—H = polar covalent; (c) H—O most polar (largest ΔEN)

Q4 (Molecular Polarity): (a) H_2O is POLAR (polar bonds + bent shape = net dipole); (b) CH_4 is NONPOLAR (symmetrical tetrahedral, dipoles cancel); (c) NH_3 is POLAR (polar bonds + pyramidal asymmetry); (d) Polar bonds + asymmetric shape = polar molecule

Q5 (Multiple Bonds): (a) O=C=O with 2 lone pairs on each oxygen; (b) Linear geometry; nonpolar (symmetrical, dipoles cancel); (c) :N≡N: with 1 lone pair on each N

Q6 (Resonance): (a) [Lewis structure with one C=O and two

C—O single bonds]; (b) 3 resonance structures; (c) Trigonal planar; (d) Resonance means actual structure is average/hybrid; electrons don't move—real structure is blend of all forms

Q7 (Hybridization): (a) CH_4: sp^3 (4 electron domains); (b) CO_2: sp (2 electron domains); (c) NH_3: sp^3 (4 domains including lone pair)

Q8 (Bond Length/Strength): (a) Length: C≡C < C=C < C—C; (b) Strength: C—C < C=C < C≡C; (c) Higher bond order = shorter length = stronger bond (more electron density between nuclei)

Q9 (Ionic vs Covalent): (a) NaCl = ionic; H_2O = covalent; MgO = ionic; (b) Metal + nonmetal = ionic; nonmetal + nonmetal = covalent; large ΔEN (>1.7) = ionic; (c) Ionic = electron transfer; Covalent = electron sharing

Q10 (Conceptual): (a) 2 lone pairs on O push bonds down, creating bent shape (~104°); (b) Linear symmetry means equal and opposite C=O dipoles cancel; (c) Lone pairs only attracted to one nucleus, spread out more, repel more strongly; (d) FALSE—symmetrical molecules with polar bonds can be nonpolar (CO_2 example)