1. Predict whether each of the following types of matter will be bonded with ionic, covalent, or metallic bonds, and identify whether each will be composed of atoms, ions, or molecules of particles.
   (a) Ni
   (b) F₂
   (c) PtCl₄
   (d) C₃H₆O₂

2. Write the electron configuration notation and the electron dot notation for each:
   (a) Ni atom
   (b) Ni²⁺ ion
   (c) Ni³⁺ ion

3. Arrange each of the following groups of atoms and/or ions in order of increasing size:
   (a) Be²⁺, Mg²⁺, Ca²⁺, Sr²⁺
   (b) As³⁻, Se²⁻, Br⁻, Rb⁺

4. Write the electron dot notation for each ionic compound:
   (a) BaF₂
   (b) CaO

5. Draw Lewis structures that obey the octet rule for each of the following molecules or ions:
   (a) AsF₃
   (b) H₂Se
   (c) HI
   (d) SiBr₄

*6. Why do metal atoms achieve an octet configuration in compound formation?

*7. Why do nonmetal atoms achieve an octet configuration in compound formation?

*8. Predict whether each of the following will be bonded with ionic, covalent, or metallic bonds:
   (a) H₂CO₃
   (b) NaOH
   (c) brass (65% copper and 35% zinc)

*9. Arrange each of the following groups of atoms and/or ions in order of increasing size:
   (a) V, V⁺, V²⁺, V³⁺
   (b) P, P⁺, P²⁻, P³⁻
EXTRA HOMEWORK 2B

1. For each of the following diatomic molecules, (1) draw the Lewis structure, (2) identify the bond order of the bond in each molecule, (3) rank each molecule from lowest to highest bond energy, and (4) rank each bond from shortest to longest bond length:
   (a) Se₂
   (b) Br₂
   (c) I₂

2. Draw Lewis structures that obey the octet rule for each of the following molecules or ions, and identify the bond order of the bonds in each:
   (a) CCl₄
   (b) SeF₂
   (c) CO
   (d) ClO₄⁻
   (e) HS⁻
   (f) CH₂Cl₂
   (g) TeO
   (h) CO₃²⁻

3. Predict which element in each of the following groups will have the highest electronegativity:
   (a) Be, B
   (b) Br, I

4. Predict which bond will be the most polar:
   (a) Mg–F or Al–F
   (b) Fe–Br or Fe–Cl

*5. For each of the following diatomic molecules, (1) draw the Lewis structure, (2) identify the bond order of the bond in each molecule, (3) rank each molecule from lowest to highest bond energy, and (4) rank each bond from shortest to longest bond length:
   (a) CO
   (b) NO
   (c) O₂

*6. For each of the following diatomic molecules, (1) draw the Lewis structure, (2) identify the bond order of the bond in each molecule, (3) pick the molecule with the lowest and the highest bond energy, and (4) pick the molecule with the shortest and the longest bond length:
   (a) H₂
   (b) As₂
   (c) Cl₂
   (b) I₂
EXTRA HOMEWORK 2C

1. Give the formal charge for each atom in the following molecules and ions.
   (a) CCl₄       (b) SeF₂       (c) CO       (d) ClO₄⁻
   (e) HS⁻       (f) CH₂Cl₂       (g) TeO       (h) CO₃²⁻

2. Draw the best Lewis structures for each of the following molecules or ions by minimizing formal charges:
   (a) SCN⁻ (C central)       (b) SCP⁻ (C central)

3. Draw Lewis structures for each of the following molecules, which have central atoms that do not obey the octet rule:
   (a) Bi₃       (b) XeF₄

4. Draw the best Lewis structures for each of the following molecules or ions by minimizing formal charges:
   (a) SO₂       (b) PO₄³⁻       (c) ClO₂⁻

*5. Three resonance structures can be drawn for carbon dioxide. Which resonance structure is best from a formal charge standpoint?

EXTRA HOMEWORK 2D

1. Draw the best Lewis structure for each of the following, and predict their shapes:
   (a) BCl₃       (b) SeO₃²⁻       (c) SF₅⁺       (d) IF₆⁺
   (e) SiH₄       (f) NO₂⁺       (g) BrF₅⁺       (h) KrF₄

2. Which one of the following molecules, O₃, ClF₃, or BF₃, will have bond angles of 120°?

*3. Draw the best Lewis structure and predict the shape for XeF₃⁻
**EXTRA HOMEWORK 2E**

1. Draw the best Lewis structure for each of the following, predict the shape of each, and predict whether each is polar or nonpolar:
   
   (a) CO₂  
   (b) ClF₃  
   (c) AsF₅  
   (d) SeF₆  
   (e) IF₅  
   (f) O₃  
   (g) Cl₃⁻  
   (h) SeI₂  
   (i) AsI₃  
   (j) HNO (N central)  
   (k) BH₃  
   (l) BH₂F

*2. Draw the Lewis structure for ozone, and predict its shape and polarity.

*3. Ozone has an experimentally determined dipole moment of 0.53 debye units, which means it is polar. Calculate the formal charges for each atom in ozone, and try to justify its actual polarity.

*4. Carbon monoxide has a much smaller dipole moment than expected. Calculate the formal charges for each atom in carbon monoxide, and try to justify its actual polarity.

**EXTRA HOMEWORK 2F**

1. A phosphorus atom can react with hydrogen to form phosphine, PH₃.
   
   (a) The phosphorus atom can bond to the three hydrogen atoms without undergoing hybridization. If this is the case, name the bonds in the phosphine molecule, and predict the bond angle in the molecule.
   
   (b) The phosphorus atom can bond to the three hydrogen atoms by undergoing hybridization. If this is the case, name the bonds in the phosphine molecule, and predict the bond angle in the molecule.

2. A fluorine atom can react with hydrogen to form hydrogen fluoride, HF.
   
   (a) If the fluorine does not undergo hybridization, name the bond in the molecule.
   
   (b) If the fluorine does undergo hybridization, name the bond in the molecule.

**EXTRA HOMEWORK 2G**

1. Draw the best Lewis structure for each of the following, give the hybridization of the central atom, predict the shape of each, and predict whether each is polar or nonpolar:
   
   (a) PH₃  
   (b) BF₃  
   (c) BeH₂  
   (d) TeF₄  
   (e) RnF₄  
   (f) IF₅⁻  
   (g) NH₄⁺  
   (h) KrF₃⁺

*2. For IF₇, give the hybridization of the central atom, predict the shape, and predict whether each is polar or nonpolar:
1. For carbon atoms with the following hybridizations, sketch their valence atomic orbitals using lines to represent each orbital, as you would in a bond orbital model:
   (a) sp3  
   (b) sp2  
   (c) sp2 (rotated 90º)  
   (d) sp

2. Draw the bond orbital model and label all of the bonds in the following molecules or ions:
   (a) CH₃OCH₃  
   (b) CH₃CCH  
   (c) CH₂CCHCH₃

3. Give the number of sigma and pi bonds in the following molecule:

   ![Molecule Image]

4. For the ozone molecule, O₃, draw its bond orbital model. Labeling the bonds is not necessary.

5. For the arsenate ion, AsO₄³⁻, draw the best Lewis structure and give the hybridization of the central atom. What atomic orbitals are being used for the pi bonding?

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**EXTRA HOMEWORK 2I**

1. Name each of the following molecular orbitals.
   (a) ![Molecular Orbital Image]  
   (b) ![Molecular Orbital Image]

2. For the He₂⁺ ion, (1) draw the molecular orbital energy level diagram, (2) write the electron configuration notation, (3) determine the bond order, and (4) determine if the species is paramagnetic or diamagnetic.

3. Draw a picture of the molecular orbital that would be formed from the following combinations of atomic orbitals:
   (a) 2s + 2s  
   (b) 2s − 2s

4. For each of the following diatomic species, (1) draw a molecular orbital energy level diagram, (2) write the valence electron configuration notation, (3) determine the bond order, and (4) determine if the species exists or not
   (a) Li₂  
   (b) Be₂
EXTRA HOMEWORK 2J

1. Draw pictures of each bonding and antibonding molecular orbital created from combinations of the following atomic orbitals:
   (a) 
   (b) 
   (c) 

2. For the SCl diatomic molecule, draw its molecular orbital energy level diagram.

3. For each of the following diatomic species, (1) write the electron configuration notation, (2) determine the bond order, (3) determine if the species is paramagnetic or diamagnetic, (4) indicate which one has the highest bond energy and which one has the lowest bond energy, and (5) indicate which one has the longest bond length and which one has the shortest bond length:
   (a) SCl
   (b) SCl⁻
   (c) SCl⁺

4. Draw the bond orbital model and label all of the bonds for NO₂⁻

5. For the HF diatomic molecule, (1) draw the molecular orbital energy level diagram, (2) write the electron configuration notation, (3) determine the bond order, and (4) determine if the species is paramagnetic or diamagnetic.

EXTRA HOMEWORK 2K

1. Determine the empirical formula of a compound of titanium and oxygen that is 59.9% titanium by mass.

2. A sample of a compound containing nitrogen and oxygen is decomposed in the laboratory, producing 24.5 g of nitrogen and 70.0 g of oxygen. Determine the empirical formula of the compound.

3. Determine the molecular formula of a compound that is 85.6% carbon and 14.4% hydrogen by mass, if its molar mass is 85 ± 5 g/mol.

4. Determine the molecular formula of a compound that is 43.9% carbon, 4.9% hydrogen, and 51.2% nitrogen by mass, if its molar mass is 160 ± 10 g/mol.

5. A compound, XF₅, is 42.81% fluorine by mass. Identify the element X, and predict the shape of the molecule.

6. How many moles of nitrogen atoms are in 51.7 g of ammonium nitrate?

7. What are the total number of moles of atoms in 62.4 g of silver sulfate?

8. The Statue of Liberty is made of 2.0 x 10⁵ lbs. of copper sheets bolted to a framework. How many moles off copper are on the statue? (1 lb = 454 g)
EXTRA 2A ANSWERS

1. (a) metallic, atoms  (b) covalent, molecules  (c) ionic, ions  (d) covalent, molecules

2. (a) [Ar]4s\(^2\)3d\(^8\)  (b) [Ar]3d\(^8\)  (c) [Ar]3d\(^7\)

3. (a) Be\(^{2+}\), Mg\(^{2+}\), Ca\(^{2+}\), Sr\(^{2+}\)  (b) Rb\(^+\), Br\(^-\), Se\(^{2-}\), As\(^{3-}\)

4. (a) Ba\(^{2+}\):\(\text{F}^\cdot\)\(\text{F}^\cdot\)\(\text{F}^\cdot\)  (b) Ca\(^{2+}\):\(\text{O}^2-\)

5. (a) \(\text{F}^+\)  (b) H  (c) H\(\text{I}^-\)  (d) \(\text{O}^\cdot\)

\(\text{F}^-\)\(\text{As}^-\)\(\text{F}^-\)  \(\text{Se}^-\text{H}^-\)

*6. Metal atoms have low electron affinities for electrons being added to their outer shell so they do not gain electrons, and low ionization energies for their valence electrons so they are lost easily, achieving an octet configuration in the next lowest energy level. Further ionization energies for the core electrons are too high to allow them to be removed.

*7. Nonmetal atoms have high ionization energies for their valence electrons so they do not lose them, and high electron affinities for electrons being added to their outer shell so they gain these electrons easily, achieving an octet configuration. Further electron affinities are low so additional electrons are not added.

*8. (a) covalent  (b) ionic and covalent  (c) metallic

*9. (a) V\(^{3+}\), V\(^{2+}\), V\(^+\), V  (b) P, P\(^-\), P\(^2-\), P\(^3-\)
EXTRA 2B ANSWERS

1. (a) \( \text{Se} \equiv \text{Se} \):
   B.O. = 2
   Highest B.E.
   Shortest B.L.
(b) \( \text{Br} \equiv \text{Br} \):
   B.O. = 1
   Lowest B.E.
   Longest B.L.
(c) \( \text{I} \equiv \text{I} \):

2. (a) \( \text{Cl} \equiv \text{Cl} \):
   B.O. = 1
(b) \( \text{S} \equiv \text{F} \):
   B.O. = 1
(c) \( \text{C} \equiv \text{O} \):
   B.O. = 3
(d) \( \text{O} \equiv \text{O} \equiv \text{O} \):
   B.O. = 1
   + 2 other R.S.
(e) \( \text{H} \equiv \text{S} \equiv \text{H} \):
   B.O. = 1
(f) \( \text{H} \equiv \text{C} \equiv \text{Cl} \equiv \text{H} \):
   B.O.'s = 1
(g) \( \text{Te} \equiv \text{O} \):
   B.O. = 2
(h) \( \text{O} \equiv \text{C} \equiv \text{O} \):
   B.O. = 1 \frac{1}{2}

3. (a) B
   (b) Br
4. (a) Mg-F
   (b) Fe-Cl

*5. (a) \( \text{C} \equiv \text{O} \):
   B.O. = 3
   B.E. = Highest
   B.L. = Shortest
(b) \( \text{N} \equiv \text{O} \):
   B.O. = 2
   B.E. = Lowest (more electron repulsion)
   B.L. = Longest (more electron repulsion)
(c) \( \text{O} \equiv \text{O} \):
   B.O. = 2

*6. (a) \( \text{H} \equiv \text{H} \):
   B.O. = 1
   B.E. = Highest
   B.L. = Shortest
(b) \( \text{As} \equiv \text{As} \):
   B.O. = 3
   B.E. = Lowest
   B.L. = Longest
(c) \( \text{Cl} \equiv \text{Cl} \):
   B.O. = 1
(d) \( \text{I} \equiv \text{I} \):
   B.O. = 1
1. Lewis structures for these molecules and ions are found in Extra Homework 2B, question 2.

   (a) $C = 0, Cl = 0$
   (b) $S = 0, F = 0$
   (c) $C = -1, O = +1$
   (d) $Cl = +3, O = -1$
   (e) $H = 0, S = -1$
   (f) $C = 0, H = 0, Cl = 0$
   (g) $Te = 0, O = 0$
   (h) $C = 0, O = 0, -1, -1$

2. (a) $\overset{\cdot}{S} = \overset{\cdot}{C} = \overset{\cdot}{N}$
   (b) $\overset{\cdot}{S} \rightarrow \overset{\cdot}{C} \equiv \overset{\cdot}{P}$

3. (a) $\overset{\cdot}{I} \rightarrow \overset{\cdot}{I}$
   (b) $\overset{\cdot}{F} \rightarrow \overset{\cdot}{Xe} \rightarrow \overset{\cdot}{F}$

4. (a) $\overset{\cdot}{O} \equiv \overset{\cdot}{S} \equiv \overset{\cdot}{O}$
   (b) $\overset{\cdot}{O} \rightarrow \overset{\cdot}{P} \rightarrow \overset{\cdot}{O}$
   (c) $\overset{\cdot}{O} \equiv \overset{\cdot}{Cl} \equiv \overset{\cdot}{O}$

*5. $\overset{\cdot}{O} \equiv C \equiv \overset{\cdot}{O}$
   $\overset{\cdot}{O} \equiv C \equiv \overset{\cdot}{O}$
   $\overset{\cdot}{O} \equiv C \equiv O$
   $\overset{\cdot}{O} \equiv C \equiv O$
   $\overset{\cdot}{O} \equiv C \equiv O$
   $\overset{\cdot}{O} \equiv C \equiv O$
   best $\overset{\cdot}{O} \equiv C \equiv O$
EXTRA 2D ANSWERS

1. (a) \[ \text{Cl} - B - \text{Cl} \]
   trigonal planar

(b) \[ \text{O}: \quad \text{O} - \text{Se} - \text{O} \]
   trigonal pyramidal + 2 other R.S.

(c) \[ \text{F}: \quad \text{S} - \text{F} \]
   trigonal bipyramidal

(d) \[ \text{F}: \quad \text{F} \]
   octahedral

(e) \[ \text{H} - \text{Si} - \text{H} \]
   tetrahedral

(f) \[ \text{O} = \text{N} = \text{O}^+ \]
   linear

(g) \[ \text{F} - \text{Br} - \text{F}^+ \]
   see-saw

(h) \[ \text{F} - \text{Kr} - \text{F} \]
   square planar

2. Only BF\(_3\) has bond angles of exactly 120º.

*3. \[ \text{F} : \quad \text{Xe} \quad \text{F} : \]
   SN = 6 with 3 lone pairs will give either a trigonal pyramidal shape with 90º angles, or a T-shape
1. (a) \(\overset{-}{\text{O}} \equiv \text{C} \equiv \overset{-}{\text{O}}\): linear nonpolar
(b) :\overset{-}{\text{F}} \equiv \text{Cl} \equiv \overset{-}{\text{F}}:\) T shape polar
(c) :\overset{-}{\text{F}} \equiv \overset{-}{\text{As}} \equiv \overset{-}{\text{F}}:\) trigonal bipyramidal nonpolar
(d) :\overset{-}{\text{F}} \equiv \overset{-}{\text{Se}} \equiv \overset{-}{\text{F}}:\) octahedral nonpolar
(e) \overset{-}{\text{F}} \equiv \overset{-}{\text{I}} \equiv \overset{-}{\text{F}}:\) square pyramidal polar
(f) \overset{-}{\text{O}} = \overset{-}{\text{O}} = \overset{-}{\text{O}}\): bent 120\(^\circ\) nonpolar
(g) :\overset{-}{\text{Cl}} \equiv \overset{-}{\text{Cl}} \equiv \overset{-}{\text{Cl}}:\) linear nonpolar
(h) :\overset{-}{\text{I}} \equiv \overset{-}{\text{Se}} \equiv \overset{-}{\text{I}}:\) bent 109.5\(^\circ\) polar
(i) :\overset{-}{\text{I}} \equiv \overset{-}{\text{As}} \equiv \overset{-}{\text{I}}:\) trigonal pyramidal polar
(j) \overset{-}{\text{H}} \equiv \overset{-}{\text{N}} \equiv \overset{-}{\text{O}}:\) bent 120\(^\circ\) polar
(k) \overset{-}{\text{H}} \equiv \overset{-}{\text{B}} \equiv \overset{-}{\text{H}}:\) trigonal planar nonpolar
(l) \overset{-}{\text{F}} \equiv \overset{-}{\text{B}} \equiv \overset{-}{\text{H}}:\) trigonal planar polar

*2. \(\overset{-}{\text{O}} = \overset{-}{\text{O}} = \overset{-}{\text{O}}\): bent 120\(^\circ\), nonpolar

*3. 

The different formal charges of each oxygen contribute to the bonds being polar. Because the \(\delta^+\) and \(\delta^-\) oxygen atoms are arranged asymmetrically, a molecular dipole is produced.

*4. \(:\overset{-}{\text{C}} \equiv \overset{-}{\text{O}}:\) 

Because the more electronegative atom oxygen has a positive formal charge (and the more electropositive atom carbon has a negative formal charge), the oxygen end of the bond is not as negative as would be expected, and the carbon end of the bond is not as positive as would be expected.
EXTRA 2F ANSWERS

1. (a) $\sigma (3p + 1s)$ 90.0º 
   (b) $\sigma (sp^3 + 1s)$ 109.5º

*2. (a) $\sigma (1s + 2p)$ (b) $\sigma (1s + sp^3)$

EXTRA 2G ANSWERS

1. (a) \[
\begin{array}{c}
\text{H} \\
\text{H} \quad \text{F} \\
\text{P} \quad \text{H}
\end{array}
\]
   $sp^3$
   trigonal pyramidal
   nonpolar

(b) \[
\begin{array}{c}
\text{:F:} \\
\text{F} \quad \text{B} \\
\text{F}
\end{array}
\]
   $sp^2$
   trigonal planar
   nonpolar

(c) \[
\begin{array}{c}
\text{H} \\
\text{Be} \\
\text{H}
\end{array}
\]
   $sp$
   linear
   nonpolar

(d) \[
\begin{array}{c}
\text{:F:} \\
\text{Te} \\
\text{F}
\end{array}
\]
   $sp^3d$
   see-saw
   polar

(e) \[
\begin{array}{c}
\text{:F:} \\
\text{Rn} \\
\text{F}
\end{array}
\]
   $sp^3d^2$
   square planar
   nonpolar

(f) \[
\begin{array}{c}
\text{:F:} \\
\text{I} \\
\text{F}
\end{array}
\]
   $sp^3d$
   linear
   nonpolar

(g) \[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{N} \\
\text{H}
\end{array}
\]
   $sp^3$
   terahedral
   nonpolar

(h) \[
\begin{array}{c}
\text{:F:} \\
\text{Kr} \\
\text{F}
\end{array}
\]
   $sp^3d$
   T-shape
   polar

*2. $sp^3d^2$, pentagonal bipyramidal, nonpolar
EXTRA 2H ANSWERS

1. (a) (b) (c) (d)

2. (a) (b) (c) (d)

   a = $\sigma (1s + sp^3)$
   b = $\sigma (sp^3 + sp^3)$
   a = $\sigma (sp + sp)$
   d = $\sigma (1s + sp^3)$
   b = $\sigma (sp + sp)$
   e = $\sigma (1s + sp)$
   c = $\sigma (sp + sp^3)$

3. 14$\sigma$, 2$\pi$

(continued on next page)
although not required to identify:

\[ a = \sigma (sp^2 + sp^2) \]

\[ b = \text{delocalized } \pi \text{ system} \]

4d orbitals from the arsenic, and 2p orbitals from the oxygens

**EXTRA 2I ANSWERS**

1. (a) \( \sigma_{1s}^a \)
   (b) \( \sigma_{1s}^b \)

2. \( (\sigma_{1s}^b)^2 \)
   B.O. = 1
diamagnetic

3. (a)
   (b)

4. (a)
   \( (\sigma_{2s}^a)^2 \)
   B.O. = 1
   Exists

(b)
   \( (\sigma_{2s}^b)^2(\sigma_{2s}^a)^2 \)
   B.O. = 0
   does not exist
EXTRA 2J ANSWERS

1. (a) 
(b) 
(c) 

2. 

3. (a) $\text{SCI}^{-}$ $(\sigma_{3s}^a)^2(\sigma_{3s}^b)^2(\pi_{3p}^b)^4(\pi_{3p}^a)^2(\pi_{3p}^b)^3$ B.O. = 1.5 paramag
(b) $\text{SCI}^{-}$ $(\sigma_{3s}^a)^2(\sigma_{3s}^b)^2(\pi_{3p}^b)^4(\pi_{3p}^a)^2(\pi_{3p}^b)^4$ B.O. = 1.0 diamag lowest BE longest BL
(c) $\text{SCI}^{+}$ $(\sigma_{3s}^a)^2(\sigma_{3s}^b)^2(\pi_{3p}^b)^4(\sigma_{3p}^b)^2(\pi_{3p}^b)^2$ B.O. = 2.0 paramag highest BE shortest BL

(continued on next page)

4. 

a = $\sigma$ (sp$^2$ + sp$^2$)
b = delocalized pi system

5. 

$(\sigma^a)^2(\sigma^b)^2(\pi^a)^4$ B.O. = 1 diamagnetic
1. TiO$_2$
2. N$_2$O$_5$
3. C$_6$H$_{12}$
4. C$_6$H$_8$N$_6$

*5. I, square pyramidal
*6. 1.29 mol N
*7. 1.40 mol atoms
*8. 1.4 x 10$^6$ mol Cu