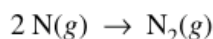


2003

7. Answer the following questions that relate to the chemistry of nitrogen.

(a) Two nitrogen atoms combine to form a nitrogen molecule, as represented by the following equation.



Using the table of average bond energies below, determine the enthalpy change, ΔH , for the reaction.

Bond	Average Bond Energy (kJ mol ⁻¹)
N — N	160
N = N	420
N ≡ N	950

2008

5. (d) Xenon can react with oxygen and fluorine to form compounds such as XeO_3 and XeF_4 . In the boxes provided, draw the complete Lewis electron-dot diagram for each of the molecules represented below.

XeO₃XeF₄

(e) On the basis of the Lewis electron-dot diagrams you drew for part (d), predict the following:

- The geometric shape of the XeO_3 molecule
- The hybridization of the valence orbitals of xenon in XeF_4

1999

(f) Predict whether the XeO_3 molecule is polar or nonpolar. Justify your prediction.

8. Answer the following questions using principles of chemical bonding and molecular structure.

(a) Consider the carbon dioxide molecule, CO_2 , and the carbonate ion, CO_3^{2-} .

- Draw the complete Lewis electron-dot structure for each species.
- Account for the fact that the carbon-oxygen bond length in CO_3^{2-} is greater than the carbon-oxygen bond length in CO_2 .

(b) Consider the molecules CF_4 and SF_4 .

- Draw the complete Lewis electron-dot structure for each molecule.
- In terms of molecular geometry, account for the fact that the CF_4 molecule is nonpolar, whereas the SF_4 molecule is polar.

2007

7. Answer the following questions about the element selenium, Se (atomic number 34).

- (a) Samples of natural selenium contain six stable isotopes. In terms of atomic structure, explain what these isotopes have in common, and how they differ.
- (b) Write the complete electron configuration (e.g., $1s^2 2s^2 \dots$ etc.) for a selenium atom in the ground state. Indicate the number of unpaired electrons in the ground-state atom, and explain your reasoning.
- (c) In terms of atomic structure, explain why the first ionization energy of selenium is
 - (i) less than that of bromine (atomic number 35), and
 - (ii) greater than that of tellurium (atomic number 52).
- (d) Selenium reacts with fluorine to form SeF_4 . Draw the complete Lewis electron-dot structure for SeF_4 and sketch the molecular structure. Indicate whether the molecule is polar or nonpolar, and justify your answer.

2002B

6. Using principles of chemical bonding and molecular geometry, explain each of the following observations. Lewis electron-dot diagrams and sketches of molecules may be helpful as part of your explanations. For each observation, your answer must include references to both substances.

- (a) The bonds in nitrite ion, NO_2^- , are shorter than the bonds in nitrate ion, NO_3^- .
- (b) The CH_2F_2 molecule is polar, whereas the CF_4 molecule is not.
- (c) The atoms in a C_2H_4 molecule are located in a single plane, whereas those in a C_2H_6 molecule are not.
- (d) The shape of a PF_5 molecule differs from that of an IF_5 molecule.
- (e) HClO_3 is a stronger acid than HClO .

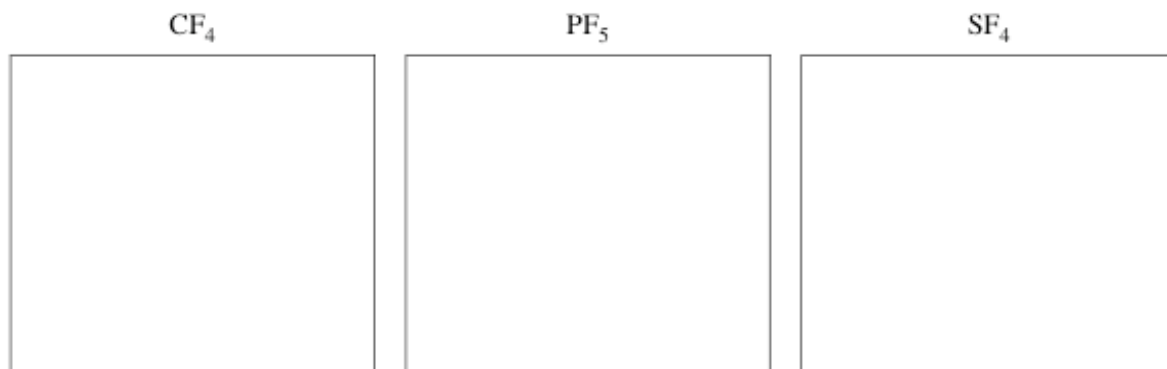
2004

8. Answer the following questions about carbon monoxide, $\text{CO}(g)$, and carbon dioxide, $\text{CO}_2(g)$. Assume that both gases exhibit ideal behavior.

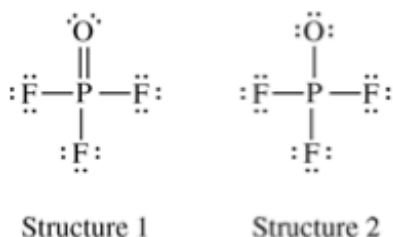
- (a) Draw the complete Lewis structure (electron-dot diagram) for the CO molecule and for the CO_2 molecule.
- (b) Identify the shape of the CO_2 molecule.

2005

- (a) In the boxes provided, draw the complete Lewis structure (electron-dot diagram) for each of the three molecules represented below.



- (b) On the basis of the Lewis structures drawn above, answer the following questions about the particular molecule indicated.
- (i) What is the $\text{F}-\text{C}-\text{F}$ bond angle in CF_4 ?
 - (ii) What is the hybridization of the valence orbitals of P in PF_5 ?
 - (iii) What is the geometric shape formed by the atoms in SF_4 ?
- (c) Two Lewis structures can be drawn for the OPF_3 molecule, as shown below.



- (i) How many sigma bonds and how many pi bonds are in structure 1?
- (ii) Which one of the two structures best represents a molecule of OPF_3 ? Justify your answer in terms of formal charge.

2005B

8. (a) Draw a complete Lewis electron-dot structure for the CS_2 molecule. Include all valence electrons in your structure.
- (b) The carbon-to-sulfur bond length in CS_2 is 160 picometers. Is the carbon-to-selenium bond length in CSe_2 expected to be greater than, less than, or equal to this value? Justify your answer.
- (c) The bond energy of the carbon-to-sulfur bond in CS_2 is 577 kJ mol^{-1} . Is the bond energy of the carbon-to-selenium bond in CSe_2 expected to be greater than, less than, or equal to this value? Justify your answer.

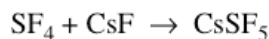
2006 7. Answer the following questions about the structures of ions that contain only sulfur and fluorine.

(a) The compounds SF_4 and BF_3 react to form an ionic compound according to the following equation.



- Draw a complete Lewis structure for the SF_3^+ cation in SF_3BF_4 .
- Identify the type of hybridization exhibited by sulfur in the SF_3^+ cation.
- Identify the geometry of the SF_3^+ cation that is consistent with the Lewis structure drawn in part (a)(i).
- Predict whether the F–S–F bond angle in the SF_3^+ cation is larger than, equal to, or smaller than 109.5° . Justify your answer.

(b) The compounds SF_4 and CsF react to form an ionic compound according to the following equation.



- Draw a complete Lewis structure for the SF_5^- anion in CsSF_5 .
- Identify the type of hybridization exhibited by sulfur in the SF_5^- anion.
- Identify the geometry of the SF_5^- anion that is consistent with the Lewis structure drawn in part (b)(i).
- Identify the oxidation number of sulfur in the compound CsSF_5 .

2006B



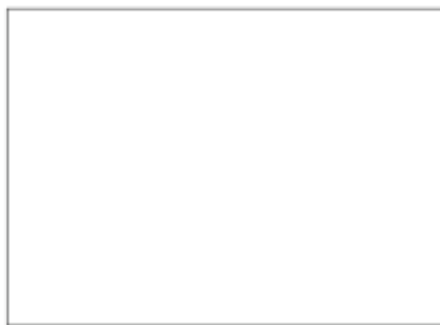
5. The species represented above all have the same number of chlorine atoms attached to the central atom.

- Draw the Lewis structure (electron-dot diagram) of each of the four species. Show all valence electrons in your structures.
- On the basis of the Lewis structures drawn in part (a), answer the following questions about the particular species indicated.
 - What is the Cl–Ge–Cl bond angle in GeCl_4 ?
 - Is SeCl_4 polar? Explain.
 - What is the hybridization of the I atom in ICl_4^- ?
 - What is the geometric shape formed by the atoms in ICl_4^+ ?

2007

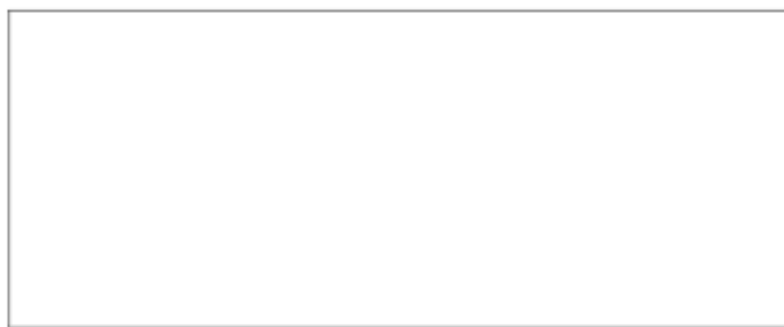
6. Answer the following questions, which pertain to binary compounds.

(a) In the box provided below, draw a complete Lewis electron-dot diagram for the IF_3 molecule.



(b) On the basis of the Lewis electron-dot diagram that you drew in part (a), predict the molecular geometry of the IF_3 molecule.

(c) In the SO_2 molecule, both of the bonds between sulfur and oxygen have the same length. Explain this observation, supporting your explanation by drawing in the box below a Lewis electron-dot diagram (or diagrams) for the SO_2 molecule.



(d) On the basis of your Lewis electron-dot diagram(s) in part (c), identify the hybridization of the sulfur atom in the SO_2 molecule.