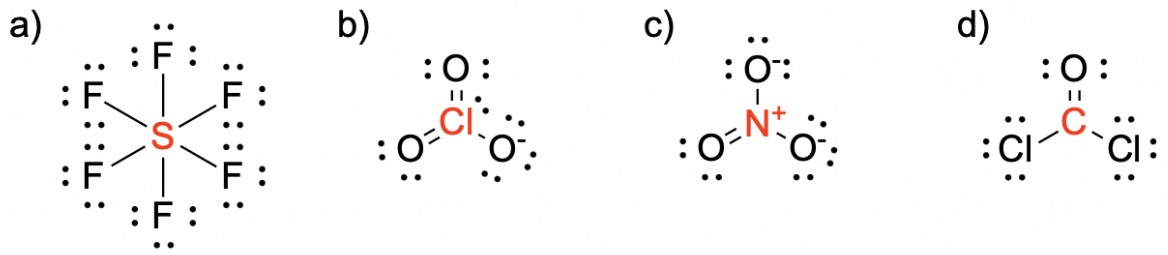
Exercises 8

Exercise 8.1
How many σ-bonds and how many π-bonds are there in (a) NO and (b) N_2O

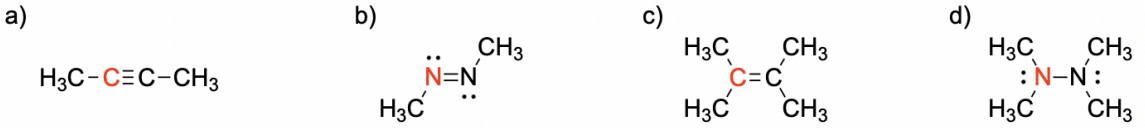
(a) NO: 1 σ-bond and 1 π-bond; (b) N_2O: 2 σ-bonds and 2 π-bonds.

Exercise 8.2
State the hybridization of the atom in boldface red type in each of the following molecules and ions: (a) **S**F_6 ; (b) **Cl**O_3^- ;(c) **N**O_3^- ;(d) O**C**Cl_2



(a) sp^3d^2; (b) sp^3; (c) sp^2; (d) sp^2

Exercise 8.3
Identify the hybrid orbitals used by the atom in boldface red type in each of the following molecules: (a) CH_3**C**CCH_3; (b) CH_3**N**NCH_3; (c) $(CH_3)_2$**C**$C(CH_3)_2$; (d) $(CH_3)_2$**N**$N(CH_3)_2$



(a) sp; (b) sp^2; (c) sp^2; (d) sp^3

Exercise 8.4
Identify the hybrid orbitals used by the atom in boldface red type in each of the following molecules: (a) H_2C**C**CH_2; (b) H_3C**C**H_3; (c) CH_3NNN; (d) CH_3C**O**OH

(a) sp; (b) sp^3; (c) sp; (d) sp^2

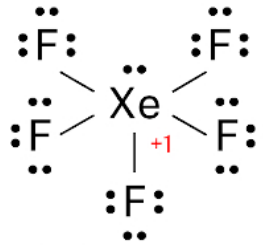
For c) the resonance structure isn't shown

Exercise 8.5

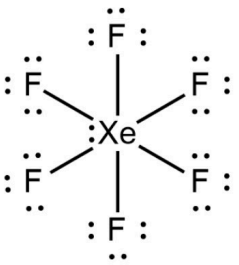
Propose one Lewis structure each for XeF_5^+ and XeF_6 that makes use of ionic-covalent resonance to preserve the octet rule for each atom.

Most stable Lewis structures are:

XeF_5^+

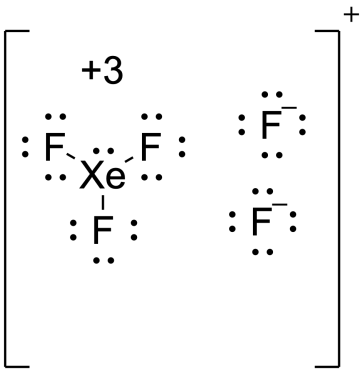


XeF_6

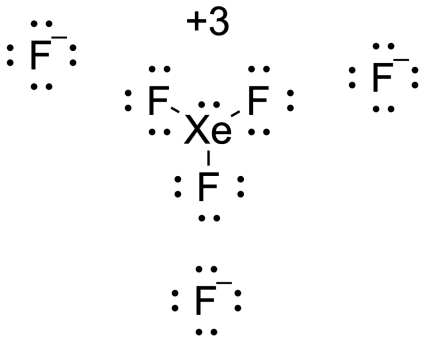


And the ionic-covalent resonance (preserving the octet rule) are, respectively:

[XeF3(+3)] [F(-1)] [F(-1)]



[XeF3(+3)] [F(-1)] [F(-1)] [F(-1)]

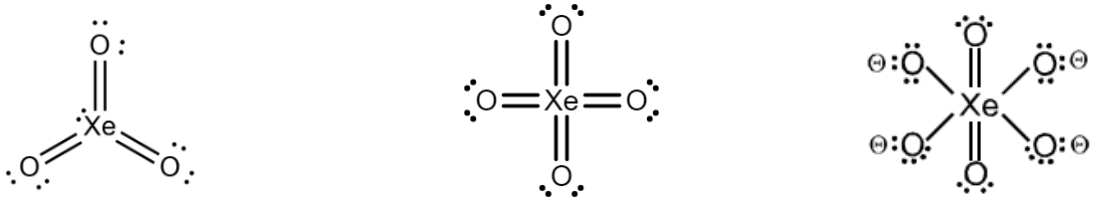


Exercise 8.6

Xenon forms XeO_3, XeO_4 and XeO_6^{4-}, all of which are powerful oxidizing agents. Draw their Lewis structures and state their bond angles and the hybridization of the xenon atom. Which would be expected to have the longest Xe-O distances? Explain your answer.

The Lewis structures:

XeO_3 **XeO_4** **XeO_6^{4-}**



The first two molecules have four groups around the central atom, leading to tetrahedral dispositions of the bonds and lone pairs.

XeO_3 is of the AX_3E type and will be trigonal pyramidal, whereas XeO_4 will be of the AX_4 type and will be tetrahedral. The XeO_6^{4-} ion is octahedral.

The hybridizations will be sp^3, sp^3, and sp^3d^2, respectively.

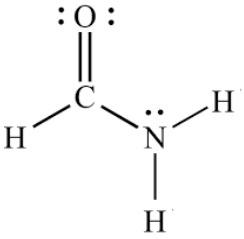
The Xe—O bonds should be longest in XeO_6^{4-} because each of those bonds should have a bond order of ca. 1.5 (accounting for resonance structures), whereas the bond orders in XeO_3 and XeO_4 will be about 2.

This agrees with experimental values: l(Xe—O) = 174 pm in XeO_3; l(Xe—O) = 176 pm in XeO_4; and l(Xe—O) = 186 pm in XeO_6^{4-}.

Exercise 8.7

Describe the structure of the formamide molecule, $HCONH_2$, in terms of hybrid orbitals, bond angles and σ- and π- bonds. The C atom is bonded to one H atom, a terminal O atom and the N atom. The N atom is also bonded to two H atoms.

The Lewis structure of formamide:



Here, both the C and the O are sp^2 hybridized, while the N is sp^3 hybridized.

The H—C—O, H—C—N, and O—C—N bond angles are each 120°.

The molecule has five sigma bonds (one each connecting the H's to the C and the N, one connecting the N to the C, and one O to the C).

Finally, there is one pi bond (between the C and the O).

List of bonds with corresponding orbitals:

σ(H1s, C2sp^2)
σ(C2sp^2, N2sp^3)
σ(C2sp^2, O2sp^2)
π(C2p, O2p)
2x σ(N2sp^3, H1s)