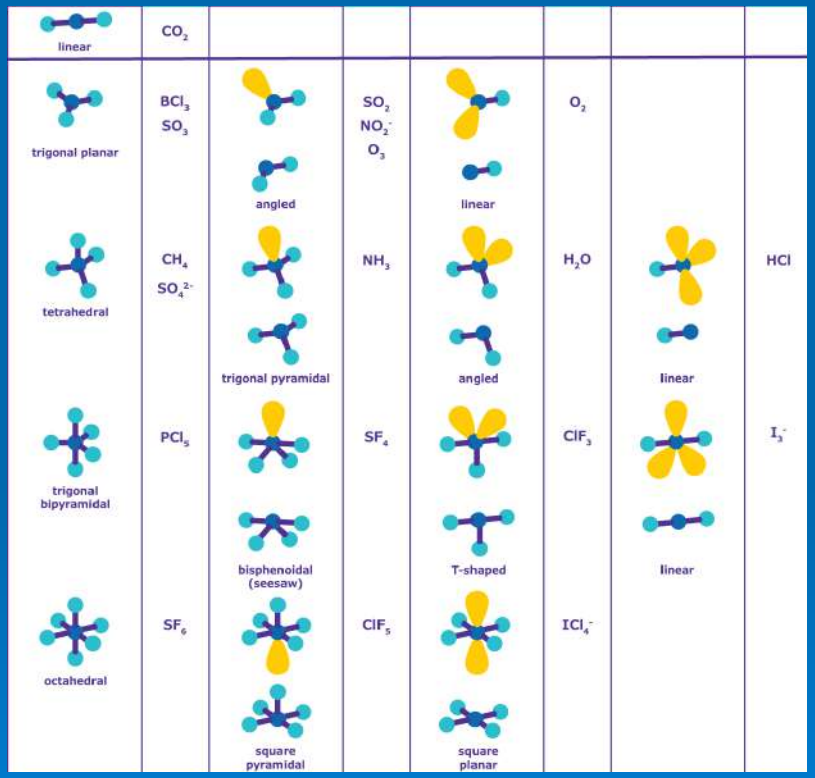
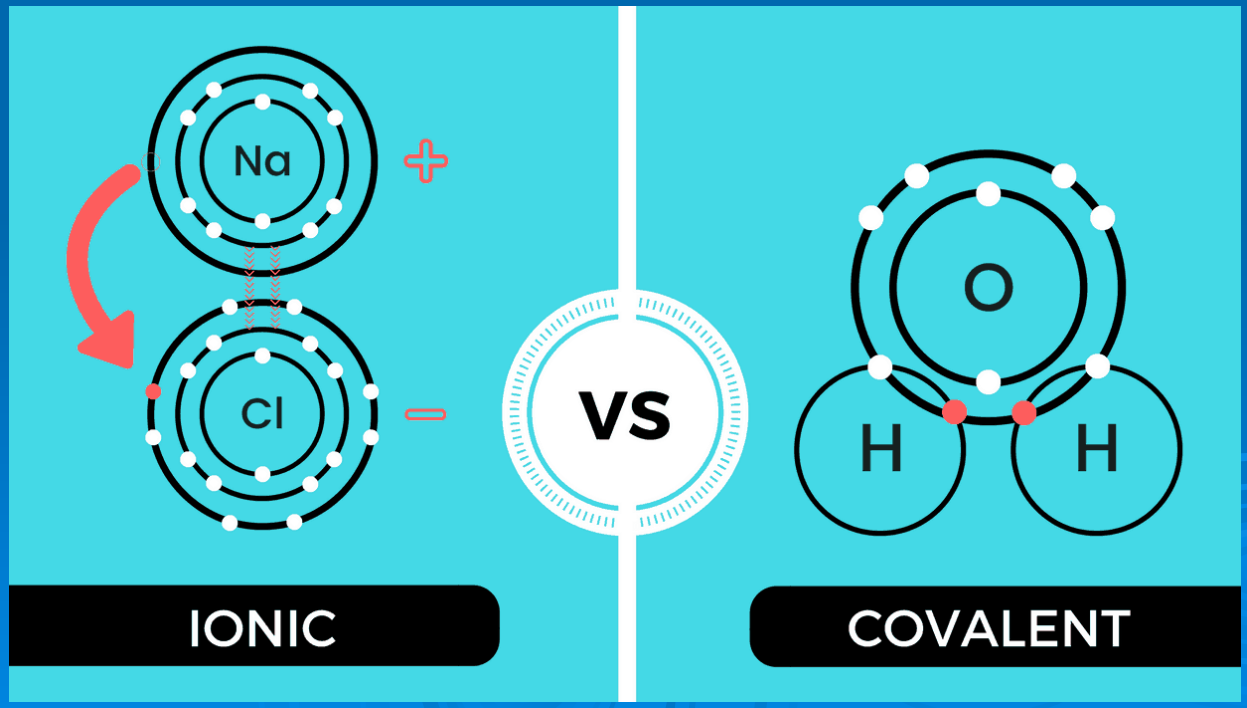
AP Chemistry
Chapter 8 and 9 Jeopardy



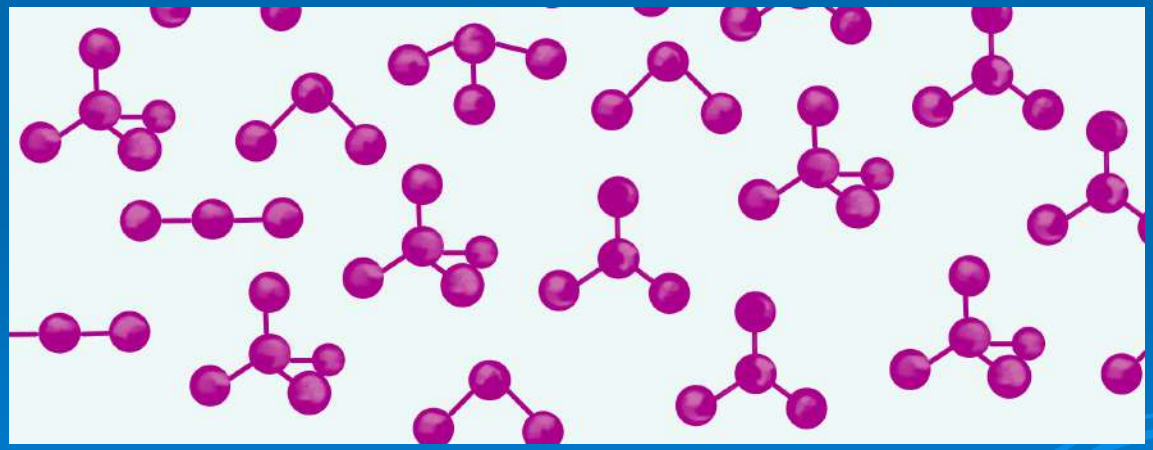
Jennie L. Borders

Round 1 – Chapter 8 Basic Concepts of Chemical Bonding



Lattice Energy	Polarity	Lewis Dot Structures	Formal Charge	Resonance	Surprise
100	100	100	100	100	100
200	200	200	200	200	200
300	300	300	300	300	300
400	400	400	400	400	400
500	500	500	500	500	500

Round 2 – Chapter 9 Molecular Geometry and Bonding Theories



Click to go to Round 2

Lattice Energy 100

Define lattice energy.

Lattice energy is the energy required to completely separate a mole of a solid ionic compound into its gaseous ions.

Lattice Energy 200

Explain the following trend in lattice energy: BaO > KF.

BaO has a larger magnitude of charge (+2 and -2), KF only has +1 and -1.

Lattice Energy 300

Explain the following trend in lattice energy: $CaF_2 > BaF_2$.

CaF_2 has a smaller cation, so lattice energy is larger.

Lattice Energy 400

Arrange the following compounds in order of lowest to highest lattice energy: ScN, KBr, MgS, NaCl.

KBr, NaCl, MgS, ScN

Lattice Energy 500

The table below shows the melting points of $MgO_{(s)}$ and $NaF_{(s)}$. Which of the following best helps explain why the melting point of $MgO_{(s)}$ is much higher than that of $NaF_{(s)}$?

Compound	Melting Point (°C)
MgO	2852
NaF	993

d.

a. The mass of F^- ions is greater than that of O^{2-} ions.

b. The mass of Mg^{2+} ions is greater than that of Na^+ ions.

c. The difference between the electronegativity values of Mg and O is smaller than the difference between the values of Na and F.

d. The charges of Mg^{2+} and O^{2-} ions are greater than those of Na^+ and F^- ions.

Polarity 100

Of the following pair, which one is a molecular substance and which one is an ionic substance: $PbCl_4$ or RbCl.

$PbCl_4$ = molecular

RbCl = ionic

Polarity 200

Of the following compounds, which is the most ionic?

a. $SiCl_4$

b. BrCl

c. PCl_3

d. Cl_2O

e. $CaCl_2$

e.

Polarity 300

Of the following single bonds, which is the LEAST polar?

a. N – H

b. H – F

c. O – F

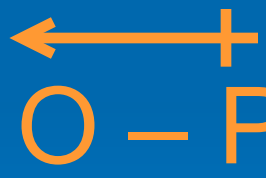
d. I – F

e. O – H

c.

Polarity 400

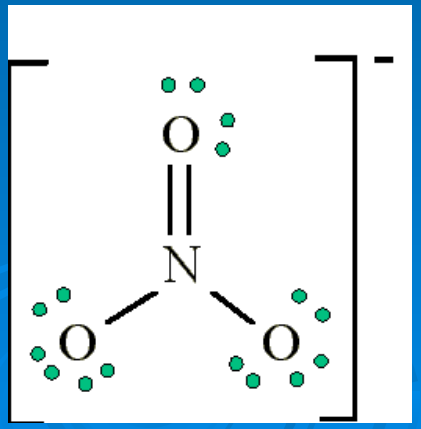
Draw the dipole moment for the following bond O – P.



Polarity 500

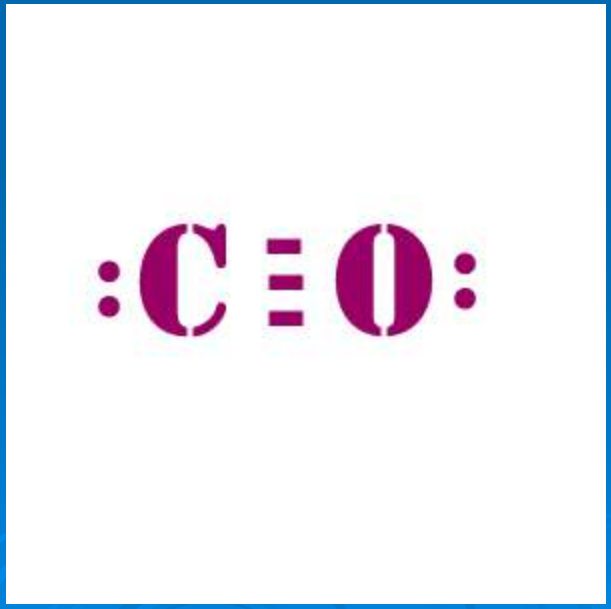
Draw the dipole moments for the following molecule: NO_3^-.

3 resonance structures, dipoles point toward the O's



Lewis Dot Structures 100

Draw the Lewis dot structures for CO.

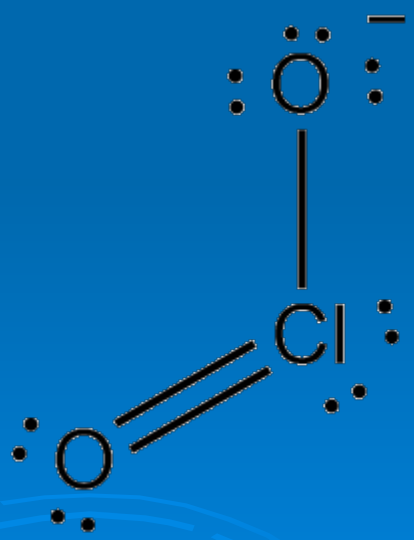


Lewis Dot Structures 200

Draw the Lewis dot structure for C_2H_2.

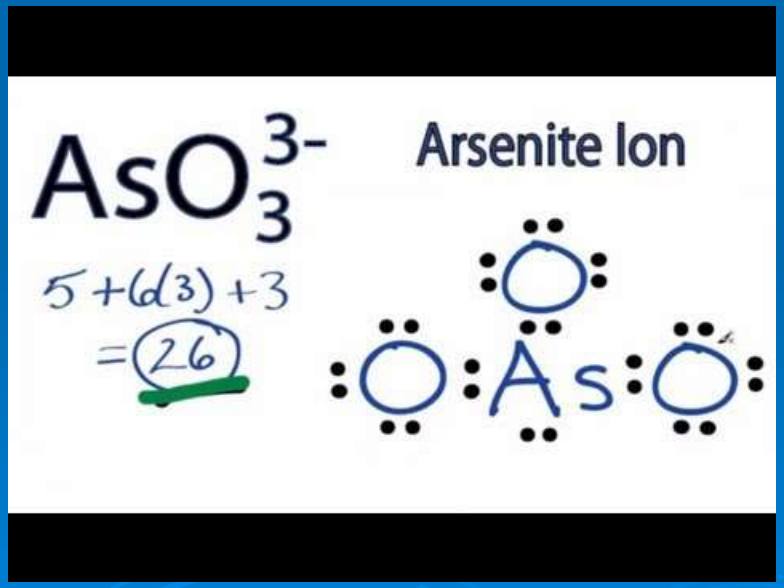
Lewis Dot Structures 300

Draw the Lewis dot structure for ClO_2^-.



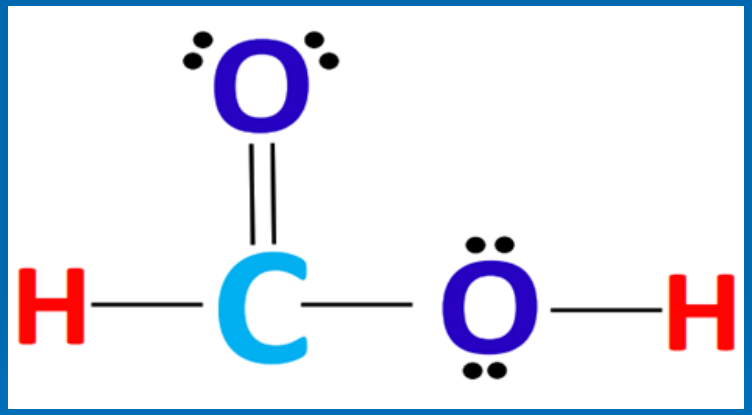
Lewis Dot Structures 400

Draw the Lewis dot structure for AsO_3^{3-}.



Lewis Dot Structures 500

a. Complete the Lewis electron-dot diagram for HCOOH. Show all bonding and nonbonding valence electrons.



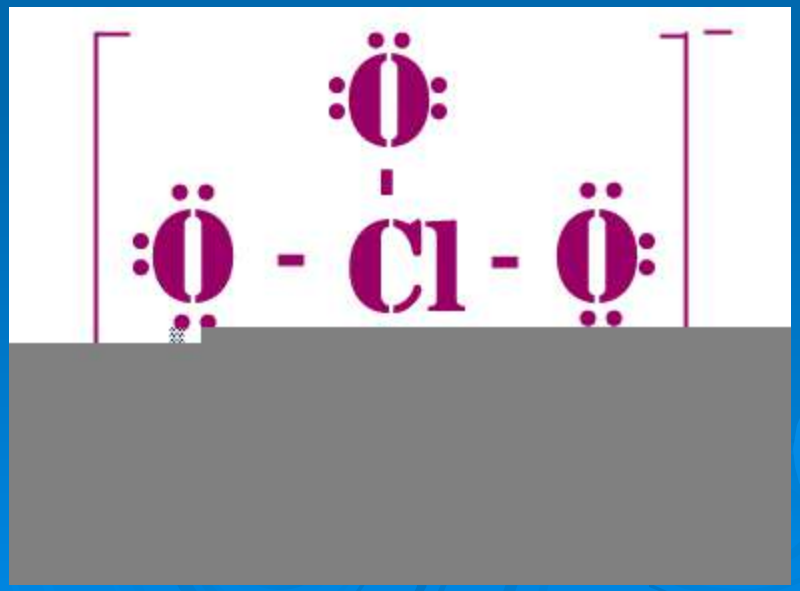
Yes, the oxidation number of C changes from +2 to +4 and H changes from +1 to 0.

b. Is the following a redox reaction? Justify your answer.

$$HCOOH_{(aq)} \rightarrow H_{2(g)} + CO_{2(g)}$$

Formal Charge 100

Determine the formal charges on the atoms of ClO_4^-.



Formal Charge 200

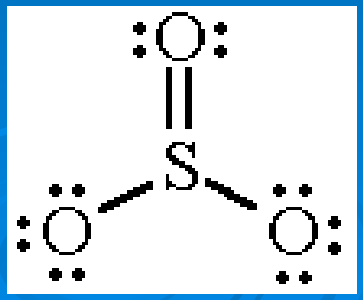
Determine the formal charges on the atoms of NO^+.

Formal charge on N = 0 and O = +1

Formal Charge 300

Determine the formal charges on the atoms of SO_3. (make sure all atoms follow the octet rule)

Formal charge on S = +2, on the double bonded O = 0, and on the 2 single bonded O = -1



Formal Charge 400

Two possible Lewis electron-dot diagrams for CO_2 are shown below. Explain in terms of formal charges why diagram Z is the better diagram. Also, identify the hybridization of the valence orbitals of the C atom in the CO_2 molecule in diagram Z.

Diagram X

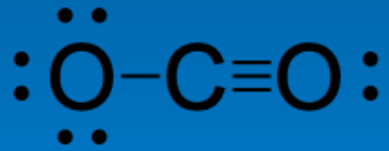


Diagram Z

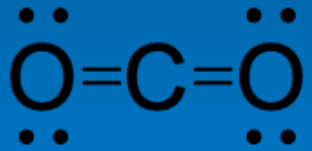


Diagram Z has a formal charge of zero on every atom, so it is preferred. The hybridization is sp.

Formal Charge 500

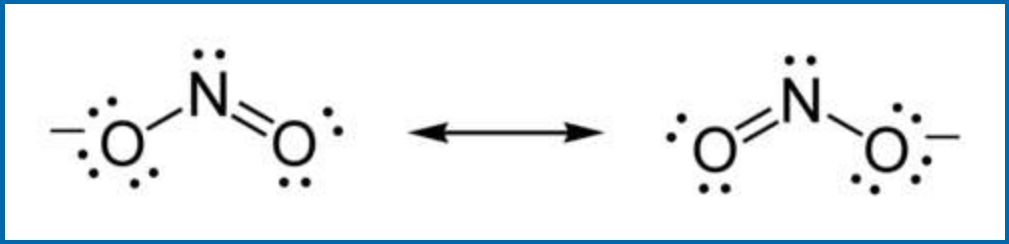
Two possible Lewis electron-dot diagrams for fulminic acid, HCNO, are shown below.

Explain why the diagram on the left is the better representation for the bonding in fulminic acid. Justify your choice based on formal charges.

Left: C = 0 and O = -1. Right: C = -1 and O = 0. The diagram on the left is better because it puts the negative formal charge on oxygen, which is more electronegative than carbon.

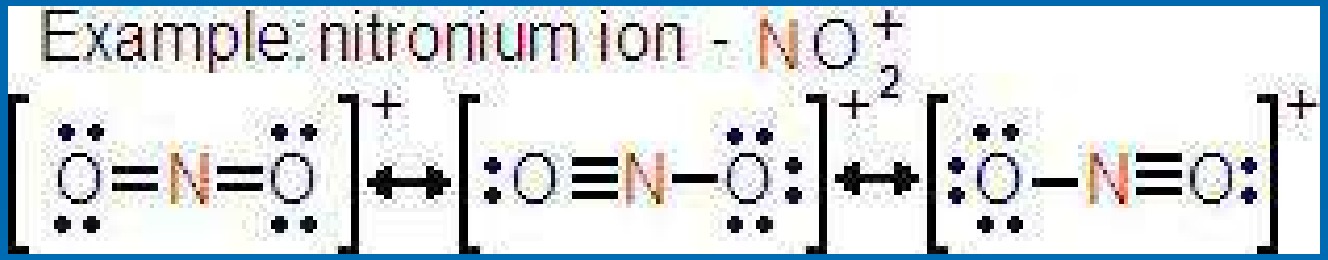
Resonance 100

Draw the resonance structures for NO_2^-.



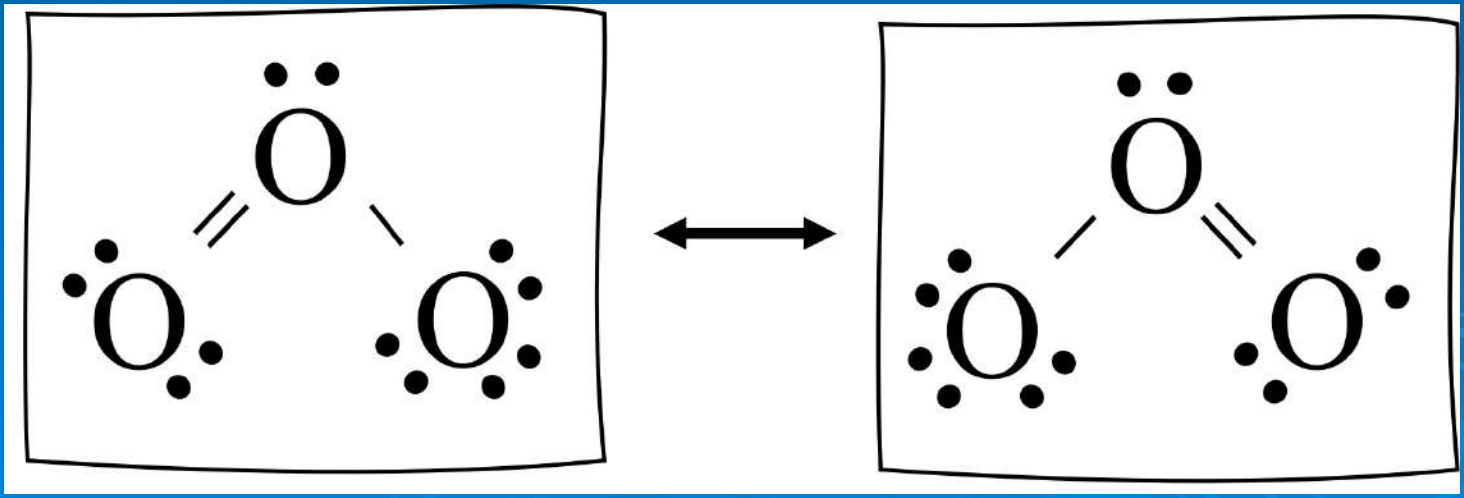
Resonance 200

Draw the resonance structures for NO_2^+.



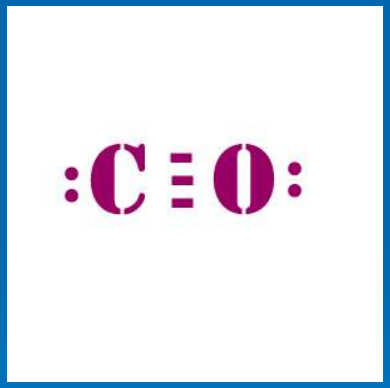
Resonance 300

The O_3 molecule has a central oxygen atom bonded to two outer oxygen atoms that are not bonded to one another. Draw the Lewis electron-dot diagram of the O_3 molecule. Include all valid resonance structures.

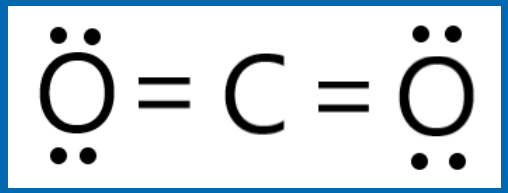


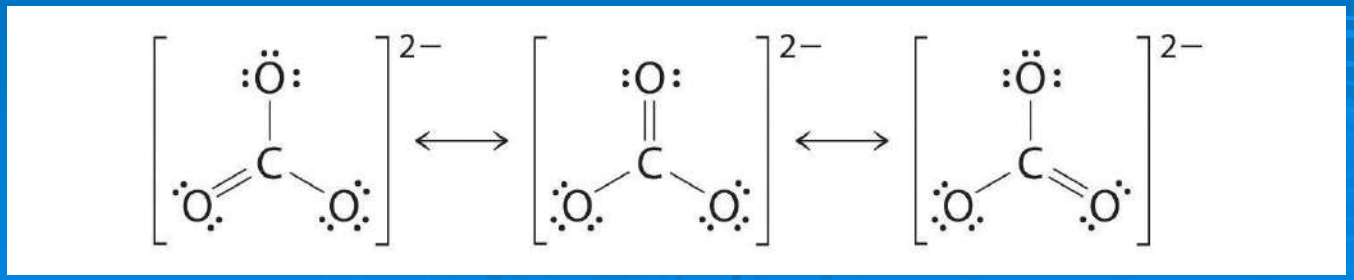
Resonance 400

Predict the ordering of the C – O bond lengths in CO, CO_2, and CO_3^{2-}.



CO, CO_2, CO_3^{2-}

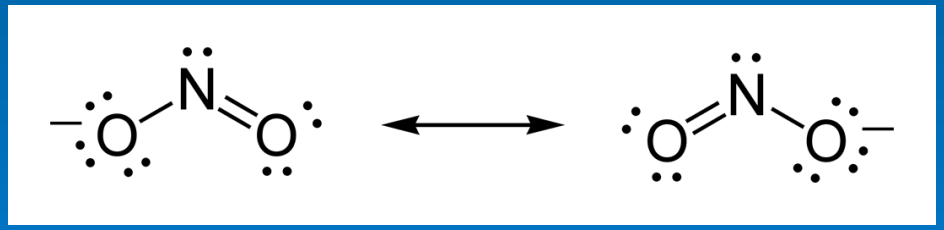


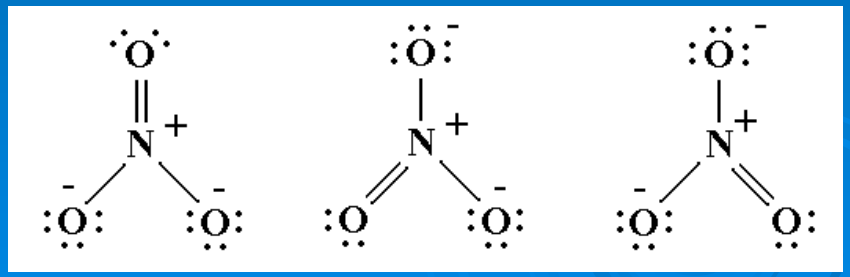


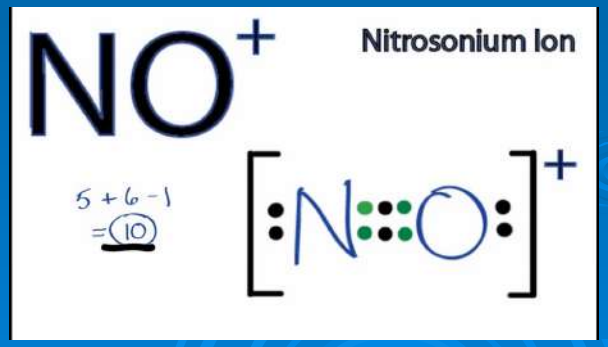
Resonance 500

Based on the Lewis structures, predict the ordering of N – O bond lengths in NO_2^-, NO_3^-, and NO^+.

NO^+, NO_2^-, NO_3^-







Surprise 100

The table below provides information about two types of steel. Which of the following best helps explain why high-carbon steel is more rigid than low-carbon steel?

Type of Steel	% Carbon	Characteristics	Uses
Low-carbon steel	< 0.2%	Malleable and ductile	Chains and nails
High-carbon steel	0.6 – 1.5%	Hard and brittle	Cutting tools

a. Elemental carbon is harder than elemental iron.

b. The additional carbon atoms within the alloy make the high-carbon steel less dense.

d.

c. The additional carbon atoms within the alloy increase the thermal conductivity of the high-carbon steel.

d. The additional carbon atoms within the alloy make it more difficult for the iron atoms to slide past one another.

Surprise 200

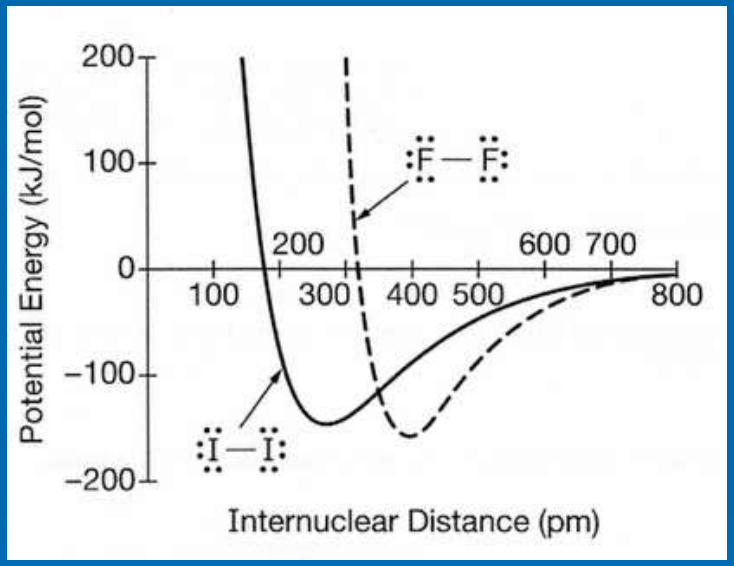
White gold is a common alloy of gold and palladium that is often used in jewelry. The atomic radii of the metals are given in the table below. A particular ring is made from an alloy that is 75 mole percent and 25 mole percent palladium. Draw a particle-level diagram of the solid alloy consisting of 12 atoms with a representative proportion of atom types. Your diagram should clearly indicate whether the alloy is interstitial of substitutional. Use empty circles for gold and shaded circles for palladium.

Element	Atomic Radius (pm)
Au	135
Pd	140

12 circles of similar size. 3 shaded and 9 empty.

Surprise 300

A student <u>incorrectly</u> sketched the potential energy curve for two fluorine atoms, shown by the dotted line.



Explain the error with the student's sketch for $F_{2(g)}$.

The minimum of the curve for F_2 should be to the left of that for I_2. since the atomic radius of F is smaller than the atomic radius of I, leading to the F-F bond being shorter than the I-I bond.

Surprise 400

The molecular formulas of diatomic bromine, chlorine, fluorine, and iodine are written below. Pick the formula of the molecule that has the longest bond length. Justify your answer in terms of atomic structure. Br_2, Cl_2, F_2, I_2

I_2 has the longest bond length because the radius of the I atoms is greater than the radii of the other halogen atoms. Thus, the distance between the nuclei of atoms in I_2 is greater than it is in smaller halogens.

Surprise 500

To make Au stronger and harder, it is often alloyed with other metals, such as Cu and Ag. Consider two alloys, one of Ag and Cu and one of Au and Ag, each with the same mole fraction of Au. If the Au/Cu alloy is harder than the Au/Ag alloy, then which of the following is the best explanation based on the information in the table below?

Element	Metallic Radius (pm)	Melting Point (°C)	Common Oxidation State
Au	144	1064	1+, 3+
Cu	128	1085	1+, 2+
Ag	144	961	1+

c.

a. Cu has two common oxidation states, but Ag has only one.

b. Cu has a higher melting point than Au has, but Ag has a lower melting point than Au has.

c. Cu atoms are smaller than Ag atoms, thus they interfere with the displacement of atoms in the alloy.

d. Cu atoms are less polarizable than are Au or Ag atoms, thus Cu has weaker interparticle forces.

Free Response (Must do all 5)	Bond Angles	VSEPR Model	Polarity	Hybrid Orbitals	Multiple Bonds
200	200	200	200	200	200
400	400	400	400	400	400
600	600	600	600	600	600
800	800	800	800	800	800
1000	1000	1000	1000	1000	1000

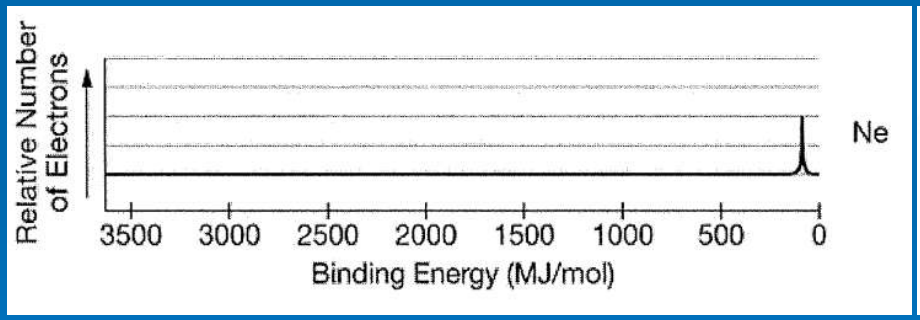
Free Response 200

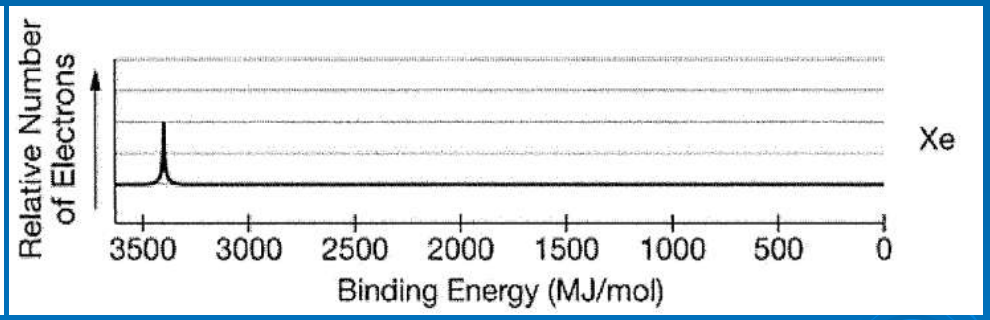
Using principles of atomic structure, explain why the atomic radius of Xe is less than that of Te.

Xe has 54 p^+ and Te has 52 p^+. They both have ve^- on the 5^{th} energy level. Since Xe has more p^+, then its ve^- have a greater attraction for the nucleus which causes the ve^- to be pulled in closer resulting in Xe having a smaller atomic radius.

Free Response 400

Photoelectron spectroscopy data for the 1s sublevel of Ne and the 1s sublevel of Xe are represented below. In terms of Coulomb's law and atomic structure, explain why the peak for Ne is positioned so far to the right of the peak for Xe.



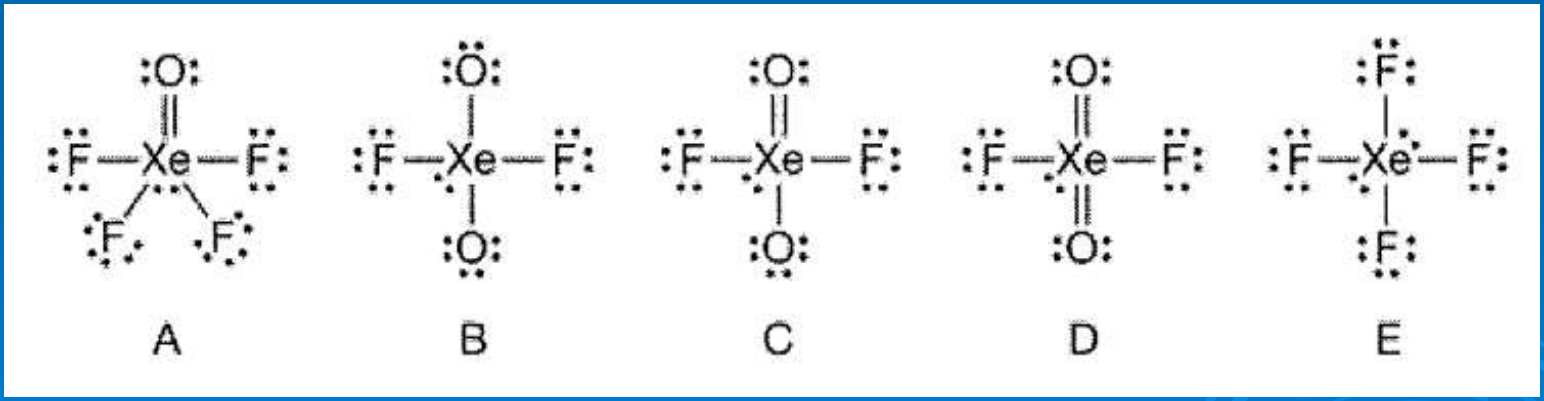


Xe has 54 p^+ and Ne has 10 p^+. Since Xe has more protons, its 1s e^- have more attraction for the nucleus which pulls them closer to the nucleus causing a larger binding energy.

Free Response 600

Three compounds that contain an element from Group 18 are $XeOF_4$, XeO_2F_2, and XeF_4. Possible Lewis electron dot diagrams for the compounds are shown below.

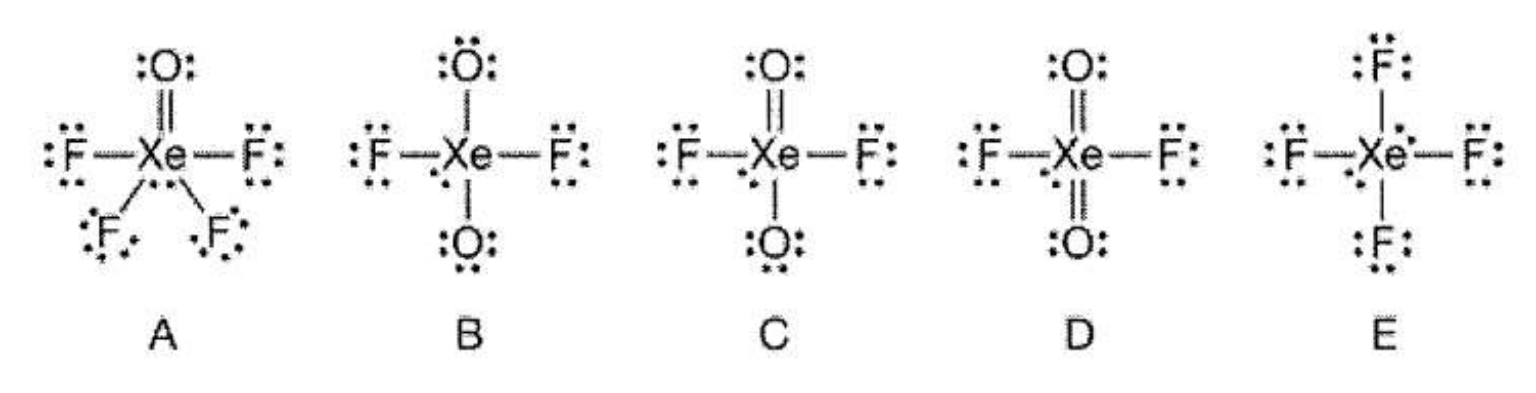
Which structure, B, C, or D, minimizes the formal charges for each atom in XeO_2F_2? Justify your choice.



Structure D because every atom has a formal charge of zero.

Free Response 800

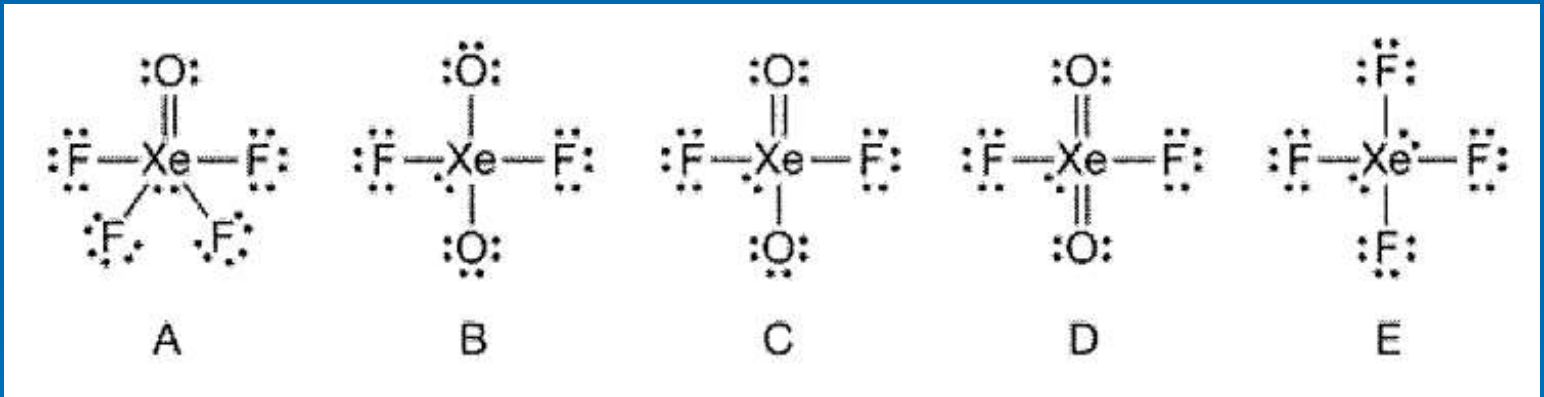
A student proposes that the energy of the Xe – to – F bond in the structure in diagram B is equal to that of the Xe – to – F bond in the structure in diagram A. Do you agree or disagree with the student's claim? Justify your answer.



Agree. The Xe – F bond in structure B and A are both since bonds, so they require the same amount of energy to break.

Free Response 1000

The dipole moment of the $XeOF_4$ molecule (diagram A) is nonzero. Identify its molecular geometry and explain how its geometry and the polarity of its bonds results in a nonzero dipole moment.

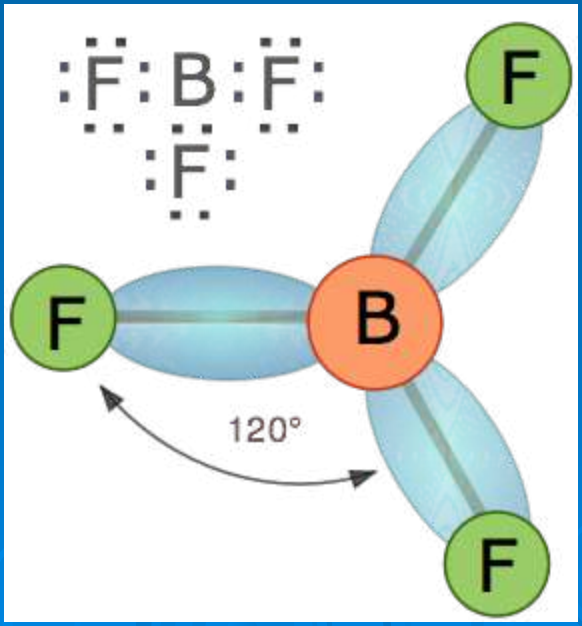


The molecular geometry is square pyramidal. Since there is a lone pair of electrons on Xe, the dipoles cannot cancel out.

Bond Angles 200

What are the bond angles in the following molecule: BF_3.

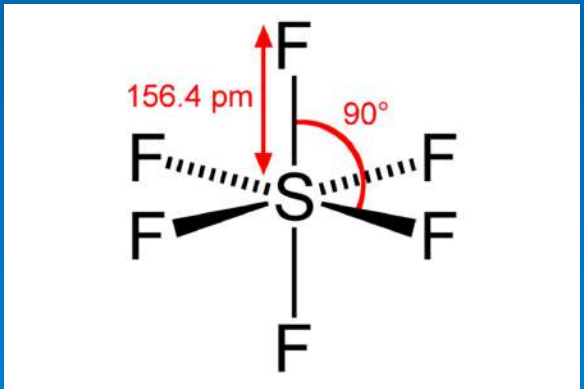
Bond angles = 120°



Bond Angles 400

What are the bond angles in the following molecule: SF_6.

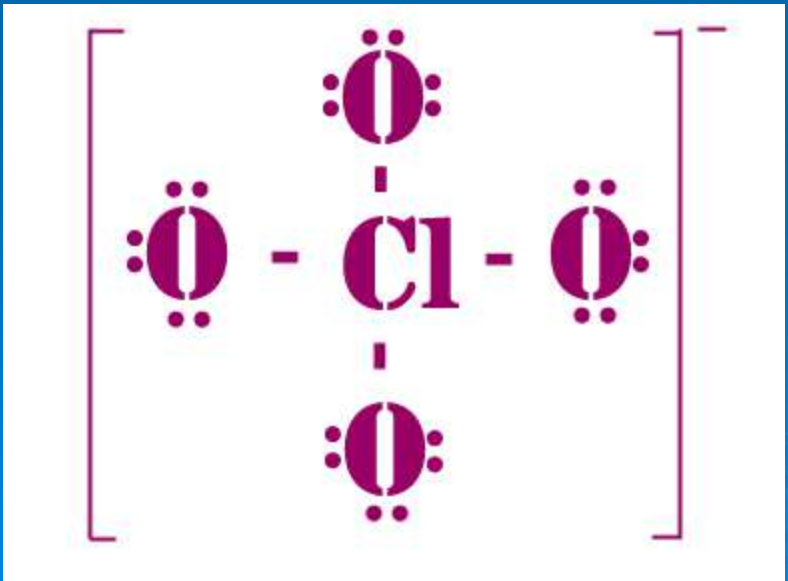
Bond angles = 90°



Bond Angles 600

What are the bond angles in the following molecule: ClO_4^-.

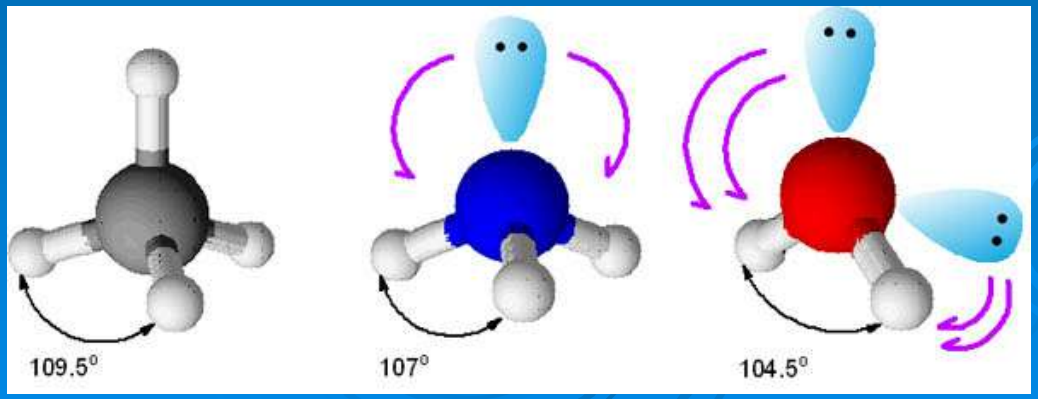
Bond angles = 109.5°



Bond Angles 800

Explain the bond angle differences in CH_4, H_2O, and NH_3.

The bond angles decreases as more lone pairs are added since lone pairs take up more space than bonded electrons.

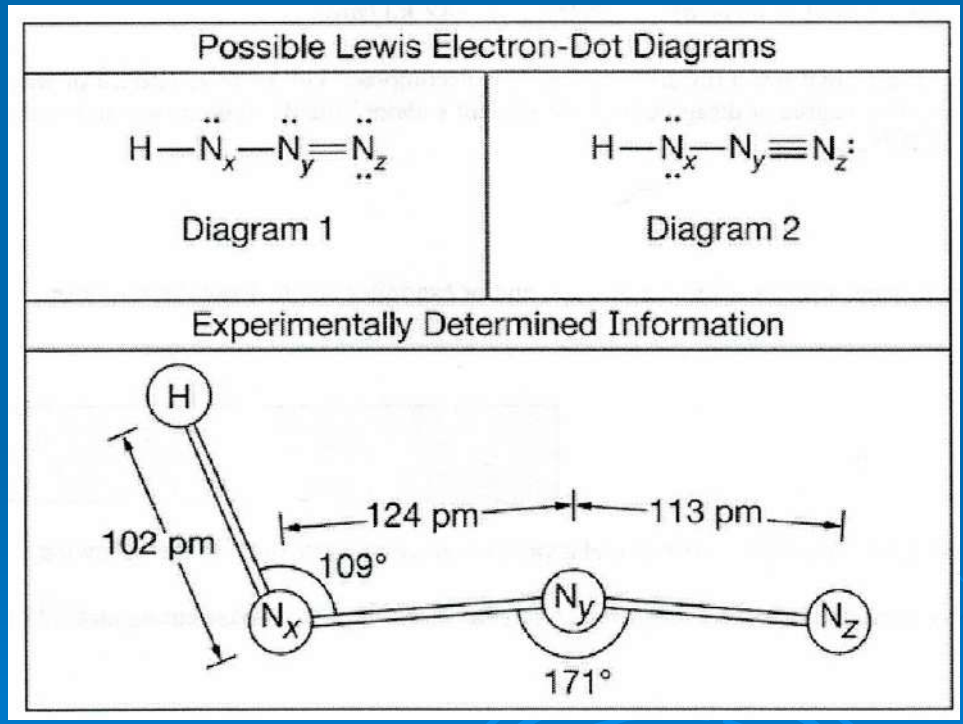


Bond Angles 1000

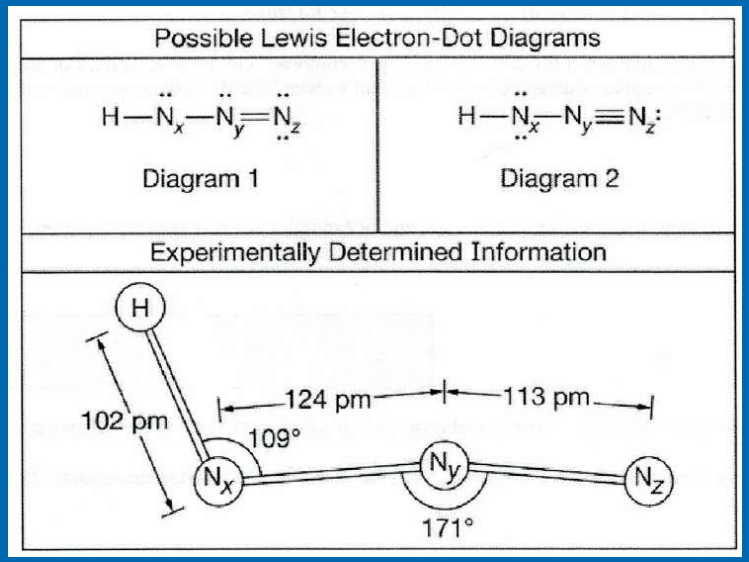
Two possible Lewis electron-dot diagrams and experimentally determined information for HN_3 are shown below.

a. Explain why diagram 2 is consistent with the experimentally determined bond lengths shown above.

b. Use VSEPR theory to explain why Diagram 1 is NOT consistent with the experimentally determined bond angles around N_y.



Bond Angles 1000 Answer



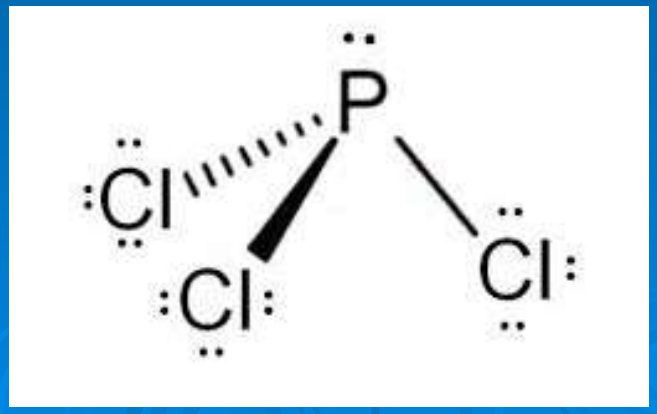
a. Diagram 2 has a single bond between N_x and N_y and a triple bond between N_y and N_z. Triple bonds are shorter than single bonds, so this is consistent with the data.

b. VSPER shows that 2 bonding and 1 lone pair around N_y make a bent geometry with a bond angle of 120°. This is inconsistent with the 171° bond angle in the data.

VSEPR Model 200

Draw a complete Lewis electron-dot diagram for PCl_3. What is the shape of the PCl_3 molecule?

MG = trigonal pyramidal

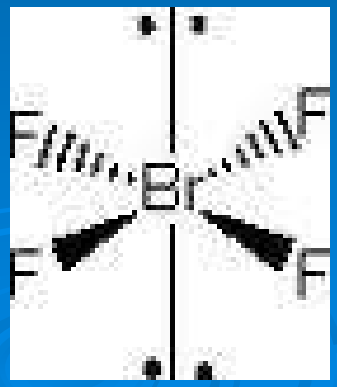


VSEPR Model 400

What is the molecular geometry and electron domain geometry of the following molecule: BrF_4.

MG = square planar

EDG = octahedral



VSEPR Model 600

Which of the following has molecules with a pyramidal shape?

a. $NH_{3(g)}$
b. $BH_{3(g)}$
c. $H_{2(g)}$
d. $H_2S_{(g)}$
e. $HBr_{(g)}$

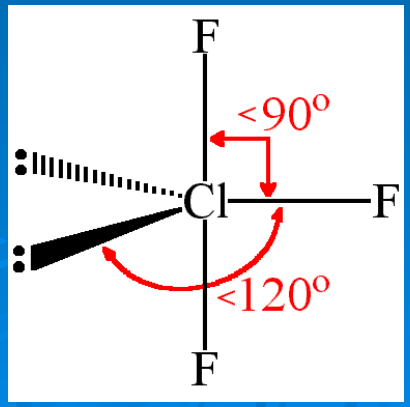
a.

VSEPR Model 800

What is the molecular geometry and electron domain geometry of the following molecule: ClF_3.

MG = T-shaped

EDG = trigonal bipyramidal



VSEPR Model 1000

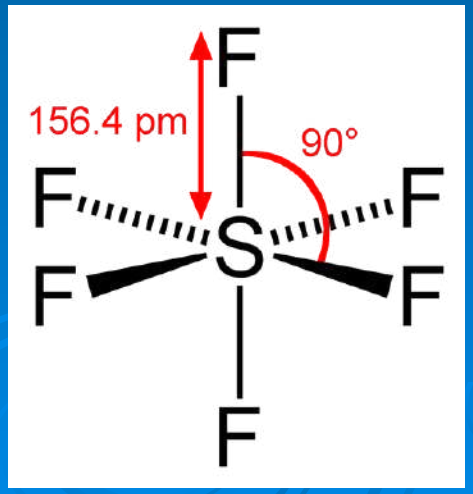
An unknown gas, D, reacts with fluorine gas to form the compound $DF_{4(g)}$. A student claims that if element D is in group 18, then the molecular geometry of $DF_{4(g)}$ is tetrahedral. Do you agree or disagree with the student? Justify your answer in terms of VSEPR theory.

Disagree. If D is in group 18, then DF_4 has a total of 36 ve^-. This would make the geometry square planar instead of tetrahedral because the 2 extra lone pairs would go on D.

Polarity 200

Is the following molecule polar or nonpolar: SF_6. (If polar, show the overall dipole moment.)

Nonpolar – dipoles all point towards the F's and cancel



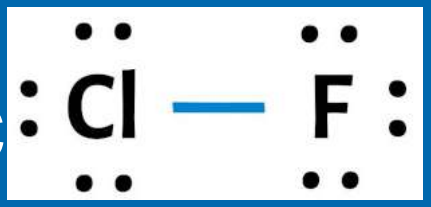
Polarity 400

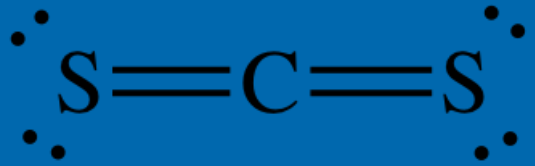
Is the following molecule polar or nonpolar: IF. (If polar, show the overall dipole moment.)

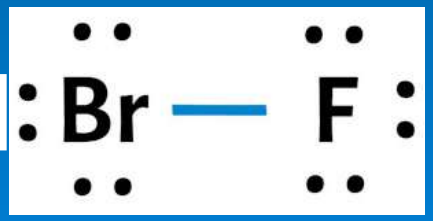
Polar – dipole points towards the F

Polarity 600

Which of the following Lewis electron-dot diagrams represents the molecule that is the most polar?

a.c 



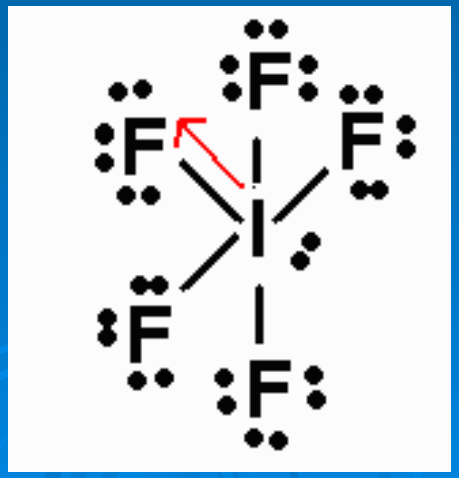
b.d 

b.

Polarity 800

Is the following molecule polar or nonpolar: IF_5. (If polar, show the overall dipole moment.)

Polar – dipoles point towards the F's



Polarity 1000

The BF_3 molecule is nonpolar, whereas the NF_3 molecule is polar. Which of the following statements accounts for the difference in polarity of the two molecules?

a. In NF_3, each F is joined to N with multiple bonds, whereas in BF_3, each F is joined to B with single bonds.

b. N-F bonds are polar, whereas B-F bonds are nonpolar.

d.

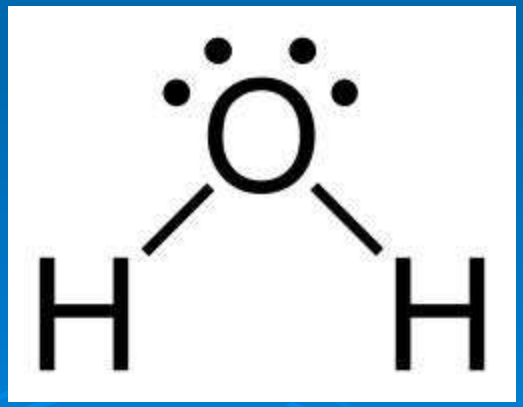
c. NF_3 is an ionic compound, whereas BF_3 is a molecular compound.

d. Unlike BF_3, NF_3 has a nonplanar geometry due to an unshared pair of electrons on the N atom.

Hybrid Orbitals 200

What is the hybridization of the molecule H_2O?

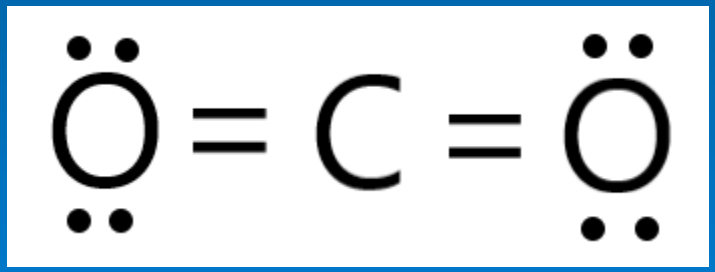
sp^3



Hybrid Orbitals 400

What is the hybridization of the molecule CO_2?

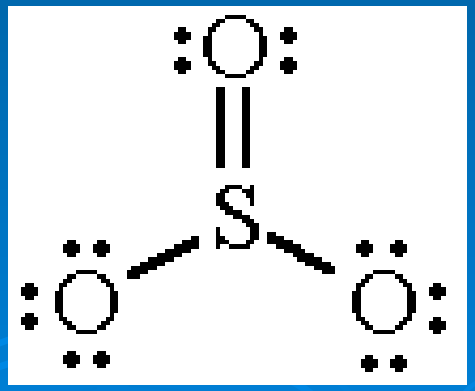
sp



Hybrid Orbitals 600

What is the hybridization of the molecule SO_3?

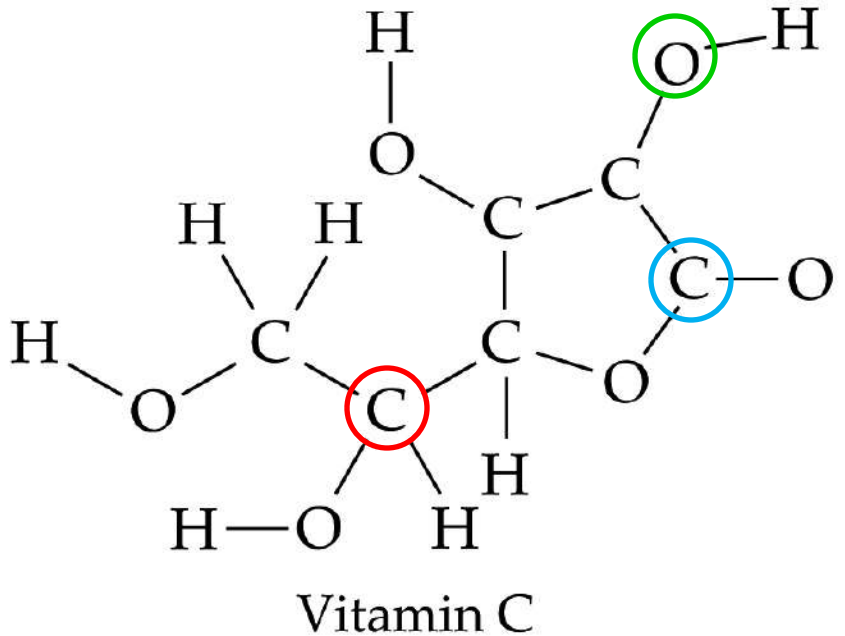
sp^2



Hybrid Orbitals 800

Below is the structure for vitamin C.

List the hybridization for each circled atom.



Vitamin C

Green = sp^3

Blue = sp^2

Red = sp^3

Hybrid Orbitals 1000

Which of the following molecules represented below contains carbon with sp^2 hybridization?

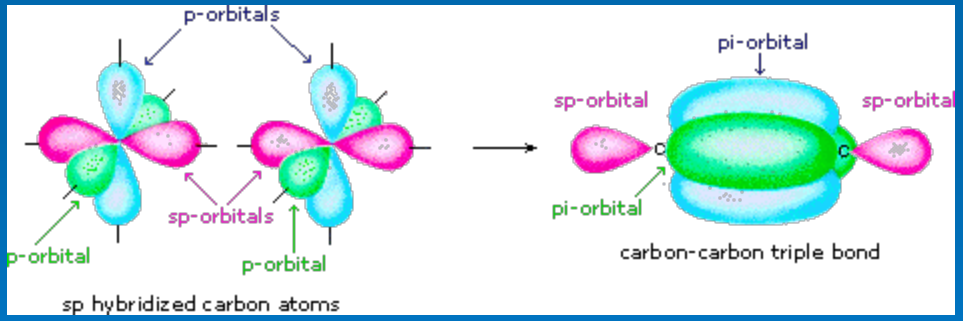
a. CH_4
b. CH_2Cl_2
c. C_2H_6
d. $C_2H_2Cl_2$
e. $C_2H_4Cl_2$

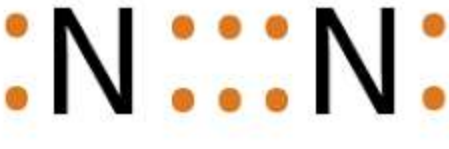
d.

Multiple Bonds 200

How many sigma and pi bonds are in N_2?

1 sigma and 2 pi bonds

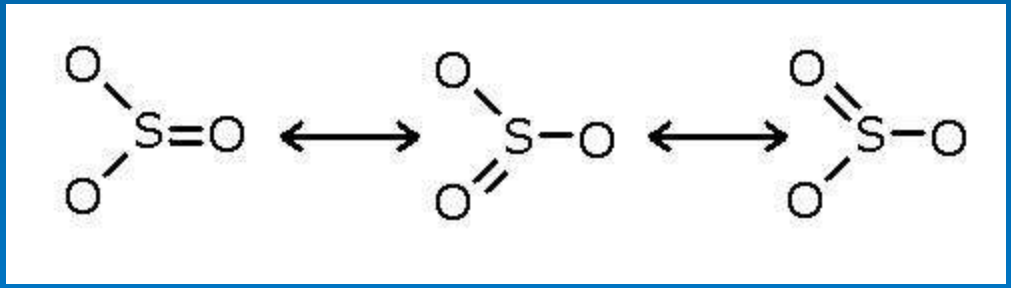




Multiple Bonds 400

Are the bonds in SO_3 localized or delocalized?

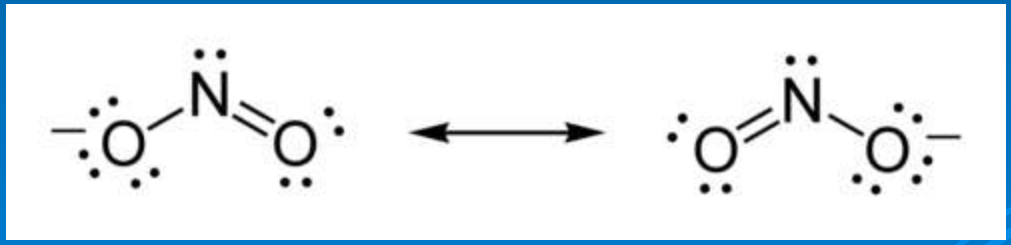
delocalized



Multiple Bonds 600

Are the bonds in NO_2^- localized or delocalized?

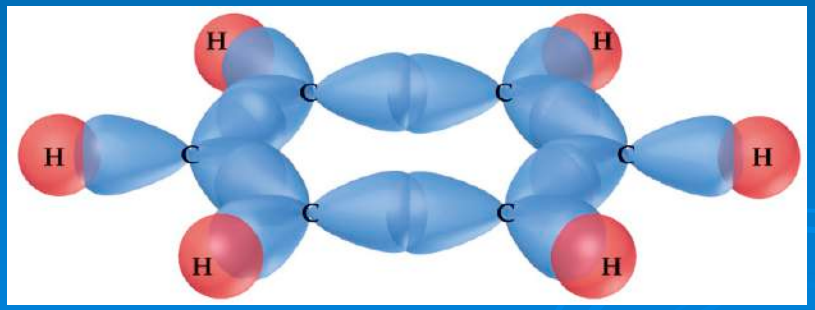
delocalized

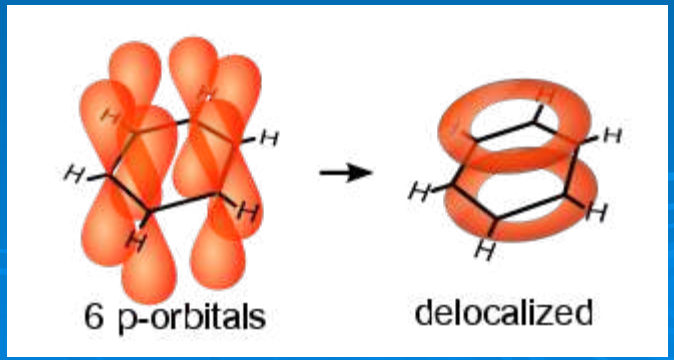


Multiple Bonds 800

Explain the sigma and pi bonds in benzene.

The C-H bonds are all sigma bonds. The C-C/C=C bonds are delocalized pi and sigma bonds.





Multiple Bonds 1000

How many sigma and pi bonds are in 1 – propene (C_3H_6)

8 sigma bonds and 1 pi bond