Solutions for Organic Chemistry 1st Edition by Mullins

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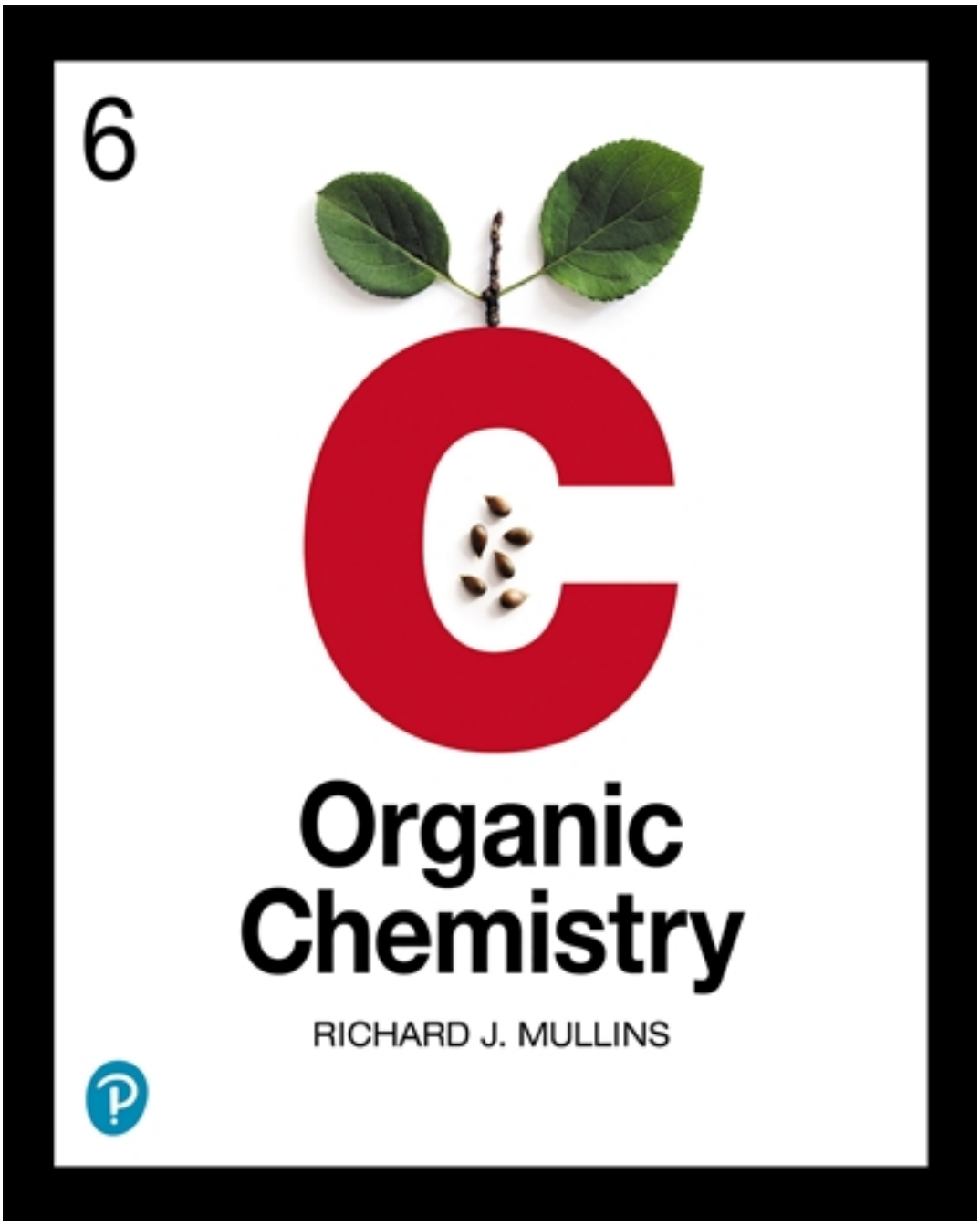



# Solutions

# 2 GENERAL CHEMISTRY TRANSLATED: FINDING THE ELECTRONS

## ASSESSMENTS

### A2.1

a. Answer:
C:$1s^2 2s^2 2p^2$

b. Answer:
N:$1s^2 2s^2 2p^3$

c. Answer:
O: $1s^2 2s^2 2p^4$

d. Answer:
F: $1s^2 2s^2 2p^5$



e. Answer:
H: $1s^1$

### A2.2

Answer:

They have the same number of valence shell electrons.

Fully Worked Solution:

Elements in the same group react similarly because they have the same number of valence shell electrons. They require the same number of bonds/electrons to complete their valence shell and attain a noble-gas configuration.

### A2.3

Answer:

Na Mg Si C N O F

Least electronegative Most electronegative

Fully Worked Solution:

Sodium's electronegativity is 0.9, magnesium's electronegativity is 1.2, silicon's electronegativity is 1.8, carbon's electronegativity is 2.5, nitrogen's electronegativity is 3.0, oxygen's electronegativity is 3.5, and fluorine's electronegativity is 4.0.

**A2.4**

a. Answer:
C: four valence shell electrons, can form four bonds

b. Answer:
N: five valence shell electrons, can form three bonds

c. Answer:
O: six valence shell electrons, can form two bonds

d. Answer:
F: seven valence shell electrons, can form one bond

e. Answer:
H: one valence shell electron, can form one bond

**A2.5**

Answer:

Argon has eight valence shell electrons and a filled outer shell. It does not need to form bonds to fill an octet.

**A2.6**

Answer:

The ball always rolls downhill.
Negatives attack positives.



**A2.7**

Answer:

79.903 amu

Fully Worked Solution:

$$\begin{aligned}&(78.918\ \text{amu} * 0.507)\\ &+ (80.916\ \text{amu} * 0.493)\\ &= \ 79.903\ \text{amu}\end{aligned}$$

**A2.8**

Answer:

75.76% $^{35}$Cl, 24.24% $^{37}$Cl

Fully Worked Solution:

$$(34.969\ \text{amu} * x) + (36.966\ \text{amu} * y) = 35.453\ \text{amu}$$

$$x + y = 1 \quad \therefore \quad y = 1 - x$$

$$(34.969\ \text{amu} * x) + (36.966\ \text{amu} * (1 - x)) = 35.453\ \text{amu}$$

$$34.969\ \text{amu}(x) + 36.966\ \text{amu} - 36.966\ \text{amu}(x) = 35.453\ \text{amu}$$

$$36.966\ \text{amu} - 35.453\ \text{amu} = 36.966\ \text{amu}(x) - 34.969\ \text{amu}(x)$$

$$1.513\ \text{amu} = 1.997\ \text{amu}(x)$$

$$x = 0.7576$$

$$y = 1 - 0.7576 = 0.2424$$

$\therefore$ 75.76% $^{35}$Cl, 24.24% $^{37}$Cl

**A2.9**

Answer:

Electrons will be added to the 5p orbital before the 4f orbital. The 5p orbital is lower in energy than the 4f orbital; thus the 5p orbital will be filled first.

**A2.10**

a. Answer:


Fully Worked Solution:

Electrons in the 2p orbital are being paired before each orbital is occupied. Move one electron to the second 2p orbital.

b. Answer:

Hund's rule is not being followed.

Fully Worked Solution:

Hund's rule is not being followed. When two or more orbitals are degenerate (equal in energy), one electron is placed in each orbital with parallel spins before pairing electrons.

**A2.11**

Answer:

The 4s orbital is lower in energy than the 3d orbital.

Fully Worked Solution:



The 4s orbital is filled before the 3d orbital; thus, the 4s orbital must be lower in energy than the 3d orbital.

**A2.12**

Answer:

The 3s electrons will be more reactive than the 2s. The 3s electrons are higher in energy than the 2s electrons.

Fully Worked Solution:

The 3s electrons are further from the nucleus than the 2s. They are held less strongly and are higher in energy than the 2s orbital; thus, the 3s electrons should be more reactive.

**A2.13**

a. Answer:

Si

Fully Worked Solution:

The 3p shell is larger than the 2p shell.

b. Answer:

O

Fully Worked Solution:

The extra electron in the 2p shell of fluorine contracts the orbital and decreases the atomic radius.

c. Answer:
Br
Fully Worked Solution:
The 4p shell is larger than the 3p shell.

d. Answer:
S
Fully Worked Solution:
Even though sulfur has more electrons in its valence shell than nitrogen, decreasing the atomic radius compared to phosphorus, sulfur is in the third row and the 3p orbitals are larger than the 2p orbitals. Sulfur is larger than nitrogen.

**A2.14**

a. Answer:
Beryllium loses two electrons to achieve the noble-gas configuration of helium.
Fully Worked Solution:
Beryllium's electron configuration is $1s^2 2s^2$. If it loses two electrons, the electron configuration becomes $1s^2$, the electron configuration of the noble gas helium.

b. Answer:
Aluminum loses three electrons to achieve the noble-gas configuration of neon.
Fully Worked Solution:
Aluminum's electron configuration is $1s^2 2s^2 2p^6 3s^2 3p^1$. If it loses three electrons, the electron configuration becomes $1s^2 2s^2 2p^6$, the electron configuration of the noble gas neon.



c. Answer:
Magnesium loses two electrons to achieve the noble-gas configuration of neon.
Fully Worked Solution:
Magnesium's electron configuration is $1s^2 2s^2 2p^6 3s^2$. If it loses two electrons, the electron configuration becomes $1s^2 2s^2 2p^6$, the electron configuration of the noble gas neon.

d. Answer:
Potassium loses one electron to achieve the noble-gas configuration of argon.
Fully Worked Solution:
Potassium's electron configuration is $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$. If it loses one electron, the electron configuration becomes $1s^2 2s^2 2p^6 3s^2 3p^6$, the electron configuration of the noble gas argon.

**A2.15**

a. Answer:
Oxygen gains two electrons to achieve the noble-gas configuration of neon.
Fully Worked Solution:
Oxygen's electron configuration is $1s^2 2s^2 2p^4$. If it gains two electrons, the electron configuration becomes $1s^2 2s^2 2p^6$, the electron configuration of the noble gas neon.

b. Answer:
Iodine gains one electron to achieve the noble-gas configuration of xenon.
Fully Worked Solution:
Iodine's electron configuration is $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^5$. If it gains one electron, the electron configuration becomes $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6$, the electron configuration of the noble gas xenon.

c. Answer:
Phosphorus gains three electrons to achieve the noble-gas configuration of argon.
Fully Worked Solution:
Phosphorus's electron configuration is $1s^2 2s^2 2p^6 3s^2 3p^3$. If it gains three electrons, the electron configuration becomes $1s^2 2s^2 2p^6 3s^2 3p^6$, the electron configuration of the noble gas argon.

d. Answer:
Chlorine gains one electron to achieve the noble-gas configuration of argon.
Fully Worked Solution:
Chlorine's electron configuration is $1s^2 2s^2 2p^6 3s^2 3p^5$. If it gains one electron, the electron configuration becomes $1s^2 2s^2 2p^6 3s^2 3p^6$, the electron configuration of the noble gas argon.

**A2.16**

a. Answer:
+1
Fully Worked Solution:

Lithium's electron configuration is $1s^2 2s^1$. If it loses one electron, the electron configuration becomes $1s^2$, the electron configuration of the noble gas helium.

b. Answer:
+3
Fully Worked Solution:
Aluminum's electron configuration is $1s^2 2s^2 2p^6 3s^2 3p^1$. If it loses three electrons, the electron configuration becomes $1s^2 2s^2 2p^6$, the electron configuration of the noble gas neon.

c. Answer:
+1
Fully Worked Solution:
Potassium's electron configuration is $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$. If it loses one electron, the electron configuration becomes $1s^2 2s^2 2p^6 3s^2 3p^6$, the electron configuration of the noble gas argon.

d. Answer:
+2
Fully Worked Solution:
Beryllium's electron configuration is $1s^2 2s^2$. If it loses two electrons, the electron configuration becomes $1s^2$, the electron configuration of the noble gas helium.

**A2.17**

a. Answer:
−1
Fully Worked Solution:
By losing one electron, chlorine attains the noble-gas configuration equivalent to argon.

b. Answer:
−2
Fully Worked Solution:
By losing two electrons, sulfur attains the noble-gas configuration equivalent to argon.

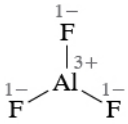
c. Answer:
−1
Fully Worked Solution:
By losing one electron, bromine attains the noble-gas configuration equivalent to krypton.

d. Answer:
−3
Fully Worked Solution:
By losing three electrons, nitrogen attains the noble-gas configuration equivalent to neon.

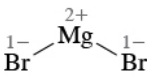
**A2.18**



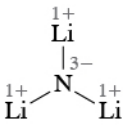
a. Answer:
$AlF_3$




b. Answer:
$MgBr_2$




c. Answer:
$Li_3N$




**A2.19**

Answer:
Stable
Fully Worked Solution:
$O^{2-}$ has an equivalent electron configuration to neon. By achieving a noble-gas configuration, the $O^{2-}$ anion is more stable than the $O^{1-}$ anion.

**A2.20**

a. Answer:
Li is more electronegative than K.

b. Answer:
O is more electronegative than N.

c. Answer:
O is more electronegative than P.

d. Answer:
B is more electronegative than Si. (We need to look up the Pauling electronegativity values for B versus Si.) Si is down and to the right of B. Electronegativity increases to the right but decreases down, so relative electronegativity cannot be easily estimated. Based on the actual electronegativity values, B (2.0) is more electronegative than Si (1.8).

**A2.21**

Answer:
Elements in higher groups have fewer filled electron shells between the nucleus and the valence shell.
Fully Worked Solution:
Atoms lower in a group have several filled electron shells between the nucleus and the valence electrons. These inner electrons "shield" the nucleus (and its positive charge) from the valence electrons. This shielding effect causes elements lower in a group to have less affinity for an electron, and thus a lower electronegativity.



**A2.22**

Answer:
With a smaller radius, valence electrons "feel" the pull of the nucleus more.
Fully Worked Solution:
A smaller atomic radius means that the valence electrons "feel" the pull of the positively charged nucleus more. This causes the atoms to have a greater affinity for a new electron, and thus a higher electronegativity.

**A2.23**

Answer:
Larger atoms are less electronegative.
Fully Worked Solution:
A larger atomic radius means that the valence electrons "feel" the pull of the positively charged nucleus less. This causes the atoms to have less affinity for a new electron, and thus a lower electronegativity.

**A2.24**

a. Answer:
NaCl is ionic.
Fully Worked Solution:
Na = 0.9, Cl = 3.0 $\Delta$EN = 2.1

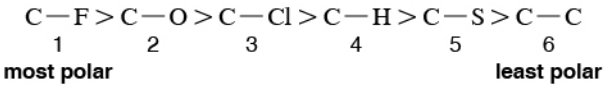
b. Answer:
C–H is covalent.
Fully Worked Solution:
C = 2.5, H = 2.1 ΔEN = 0.4

c. Answer:
O–O is covalent.
Fully Worked Solution:
O = 3.5 ΔEN = 0.0

d. Answer:
C–Cl is polar covalent.
Fully Worked Solution:
C = 2.5, Cl = 3.0 ΔEN = 0.5

**A2.25**

Answer:

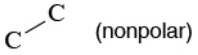



Fully Worked Solution:
C = 2.5, F = 4.0, O = 3.5, Cl = 3.0, S = 2.5, H = 2.1
ΔC–F = 1.5, ΔC–O = 1.0, ΔC–Cl = 0.5, ΔC–H = 0.4, ΔC–S = 0.0, ΔC–C = 0.0

**A2.26**

a. Answer:






Fully Worked Solution:
Both atoms have the same electronegativity. The bond is nonpolar with no δ+ or δ–.

b. Answer:


Fully Worked Solution:
Oxygen is more electronegative and has the δ– charge.

c. Answer:


Fully Worked Solution:
Carbon is more electronegative and has the δ– charge.

d. Answer:


Fully Worked Solution:
Fluorine is more electronegative and has the δ– charge.

e. Answer:

Fully Worked Solution:

Chlorine is more electronegative and has the δ− charge.

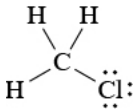
f. Answer:


Fully Worked Solution:

Both atoms have approximately the same electronegativity. The bond is nonpolar with no δ+ or δ−.

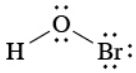
**A2.27**

a. Answer:



C: $4 - 1/2(8) = 0$
H: $1 - 1/2(2) = 0$
Cl: $7 - 6 - 1/2(2) = 0$

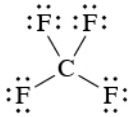
b. Answer:



H: $1 - 1/2(2) = 0$
O: $6 - 4 - 1/2(4) = 0$
Br: $7 - 6 - 1/2(2) = 0$

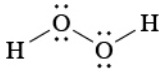


c. Answer:



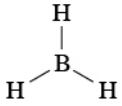
C: $4 - 1/2(8) = 0$
F: $7 - 6 - 1/2(2) = 0$

d. Answer:



H: $1 - 1/2(2) = 0$
O: $6 - 4 - 1/2(4) = 0$

e. Answer:



H: $1 - 1/2(2) = 0$
B: $3 - 1/2(6) = 0$

**A2.28**

a. Answer:

−1

Fully Worked Solution:

Al wants three electrons in the valence shell.
Al owns half of the eight bonding electrons = 4.
$3 - 4 = -1$

b. Answer:
0
Fully Worked Solution:
Al wants three electrons in the valence shell.
Al owns half of the six bonding electrons = 3.
3 − 3 = 0

c. Answer:
−1
Fully Worked Solution:
I wants seven electrons in the valence shell.
I owns eight lone pair electrons.
7 − 8 = −1

d. Answer:
+1
Fully Worked Solution:
N wants five electrons in the valence shell.
N owns half of eight bonding electrons = 4.
5 − 4 = 1

e. Answer:
0
Fully Worked Solution:
N wants five electrons in the valence shell.
N owns two lone pair electrons and half of six bonding electrons = 5.
5 − 5 = 0



f. Answer:
1
Fully Worked Solution:
O wants six electrons in the valence shell.
O owns six lone pair electrons and half of two bonding electrons = 7.
6 − 7 = −1

**A2.29**

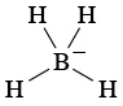
a. Answer:

H: 1 − 1/2(2) = 0
O: 6 − 6 − 1/2(2) = −1

b. Answer:

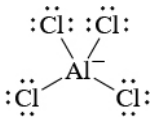
H: 1 − 0 = +1

c. Answer:



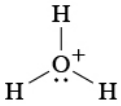
H: 1 − 1/2(2) = 0
B: 3 − 1/2(8) = −1

d. Answer:



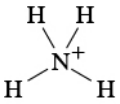
Al: $3 - 1/2(8) = -1$
Cl: $7 - 6 - 1/2(2) = 0$

e. Answer:



H: $1 - 1/2(2) = 0$
O: $6 - 2 - 1/2(6) = +1$

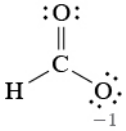
f. Answer:



H: $1 - 1/2(2) = 0$
N: $5 - 1/2(8) = +1$

**A2.30**

a. Answer:

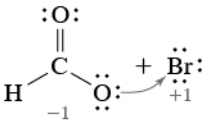


O: $6 - 6 - 1/2(2) = -1$

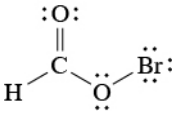
Br: $7 - 6 = +1$



b. Answer:

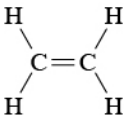


c. Answer:



**A2.31**

Answer:

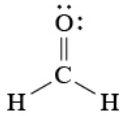


Fully Worked Solution:

Two C + 4 = 12 valence electrons. The σ-bonds can only account for ten electrons. Putting the last two electrons as a lone pair on one carbon would give it a formal −1 charge, and the other carbon a formal +1 charge. However, sharing the final two electrons as a pi-bond between the two carbons makes all atoms neutral with a full octet.

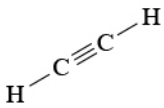
**A2.32**

a. Answer:



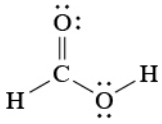
C: $4 - 1/2(8) = 0$
O: $6 - 4 - 1/2(4) = 0$
H: $1 - 1/2(2) = 0$

b. Answer:



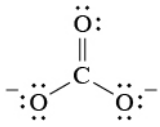
C: $4 - 1/2(8) = 0$
H: $1 - 1/2(2) = 0$

c. Answer:



C: $4 - 1/2(8) = 0$
O: $6 - 4 - 1/2(4) = 0$
H: $1 - 1/2(2) = 0$

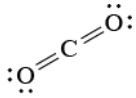
d. Answer:



C: $4 - 1/2(8) = 0$
O (C=O): $6 - 4 - 1/2(4) = 0$
O (C – O): $6 - 6 - 1/2(2) = -1$

e. Answer:

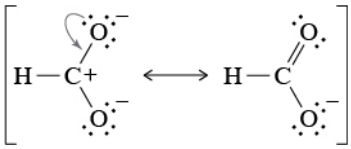




C: $4 - 1/2(8) = 0$
O: $6 - 4 - 1/2(4) = 0$

**A2.33**

Answer:



C: $4 - 1/2(6) = +1$
O: $6 - 6 - 1/2(2) = -1$

**A2.34**

a. Answer:

tetrahedral

Fully Worked Solution:

four areas of electron density around boron (four bonds) = tetrahedral

b. Answer:

tetrahedral

Fully Worked Solution:

four areas of electron density around aluminum (four bonds) = tetrahedral

c. Answer:
tetrahedral
Fully Worked Solution:
four areas of electron density (three bonds, one lone pair) around oxygen = tetrahedral

d. Answer:
tetrahedral
Fully Worked Solution:
four areas of electron density around nitrogen (four bonds) = tetrahedral

**A2.35**

a. Answer:
trigonal planar
Fully Worked Solution:
three areas of electron density around carbon (two single bonds, one double bond) = trigonal planar

b. Answer:
linear
Fully Worked Solution:
two areas of electron density around carbon (one single bond, one triple bond) = linear



c. Answer:
trigonal planar
Fully Worked Solution:
three areas of electron density around carbon (two single bonds, one double bond) = trigonal planar

d. Answer:
trigonal planar
Fully Worked Solution:
three areas of electron density around carbon (two single bonds, one double bond) = trigonal planar

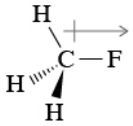
e. Answer:
linear
Fully Worked Solution:
two areas of electron density around carbon (two double bonds) = linear

**A2.36**

a. Answer:
no net dipole

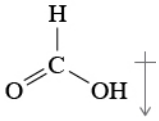
b. Answer:
no net dipole

c. Answer:

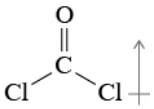



d. Answer:


e. Answer:




f. Answer:




**A2.37**

Answer:

Hydrogen contains one electron in a 1s orbital and makes one bond. No modification needs to occur with hydrogen to enable bonding; thus there is no hybridization.

**A2.38**



Answer:

Yes, nitrogen will hybridize. The lone pair will be in an $sp^3$ orbital.

Fully Worked Solution:

Ammonia has four electron domains. To minimize steric repulsion and minimize the molecular energy, the nitrogen atom will hybridize to $sp^3$ hybridization. All three bonds and the lone pair will utilize $sp^3$ orbitals.

**A2.39**

a. Answer:

$p_y$

b. Answer:

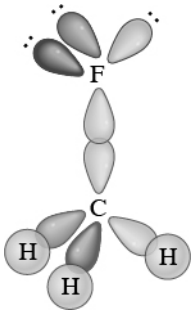
$p_x$

c. Answer:

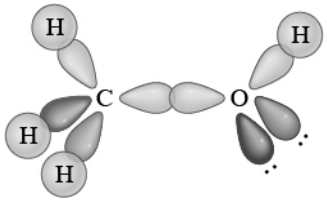
$p_z$

**A2.40**

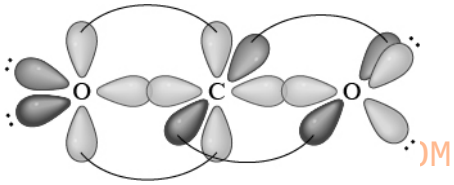
a. Answer:



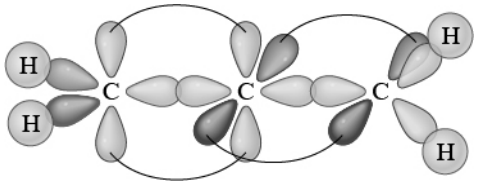

b. Answer:




c. Answer:

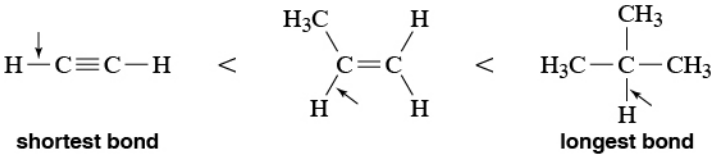



d. Answer:




**A2.41**

Answer:




Fully Worked Solution:

An sp-hybridized carbon atom is more electronegative than an $sp^3$-hybridized carbon atom. The more electronegative the carbon atom, the shorter the bond.

**A2.42**

Answer:

The carbanion will have a longer bond.

Fully Worked Solution:

The carbocation is $sp^2$ hybridized, while the carbanion is $sp^3$ hybridized. The $sp^2$ carbon atom is more electronegative and will have a shorter bond.

**A2.43**

Answer:

Sulfur is larger than oxygen.

Fully Worked Solution:

Sulfur is using $sp^3$ orbitals from the third orbital shell, while oxygen is using $sp^3$ orbitals from the second orbital shell. The third orbital shell is larger, leading to longer bond lengths.

**A2.44**

Answer:

The electrons would go into the σ* antibonding orbital.

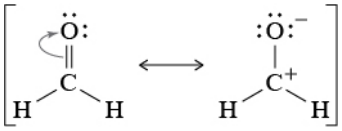
**A2.45**

Answer:

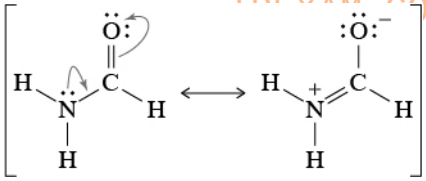
Generally, the electrons can be excited by providing a packet of energy exactly matching the difference in energy between the π- and the π*-orbitals. Specifically, this can be accomplished with light, heat, or electric current.

**A2.46**

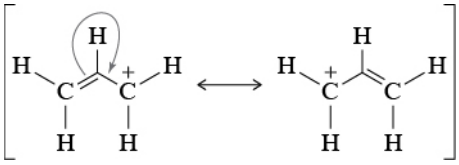
a. Answer:



b. Answer:

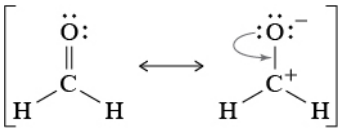


c. Answer:

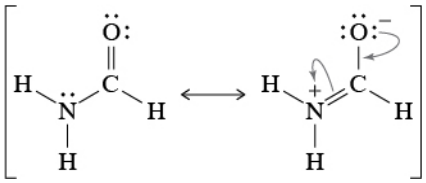


**A2.47**

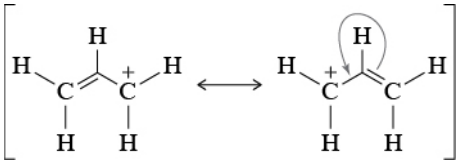
a. Answer:



b. Answer:

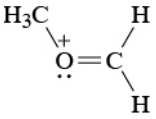


c. Answer:

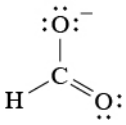


**A2.48**

a. Answer:

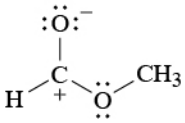


b. Answer:





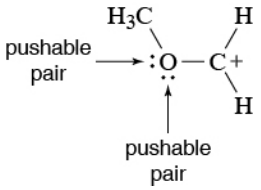
c. Answer:



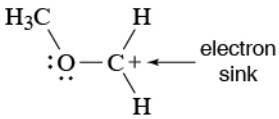
**A2.49**

a.

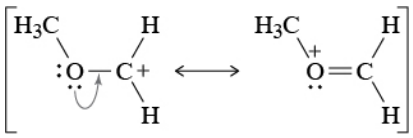
i. Answer:




ii. Answer:

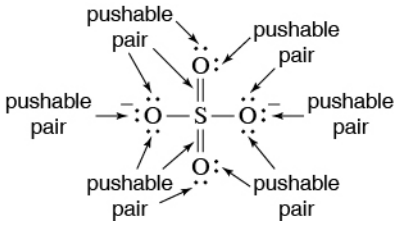


iii. Answer:

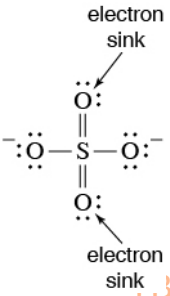


b.

i. Answer:

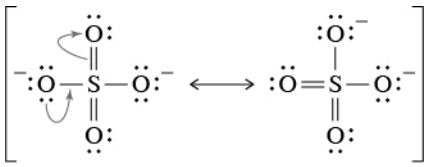



ii. Answer:



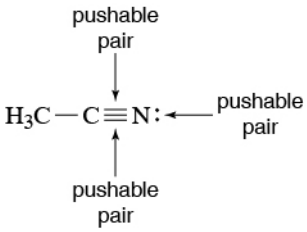



iii. Answer:

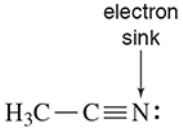


c.

i. Answer:



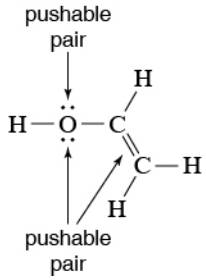

ii. Answer:



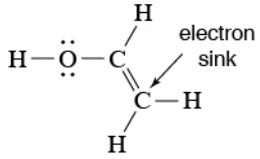
iii. Answer:

d.

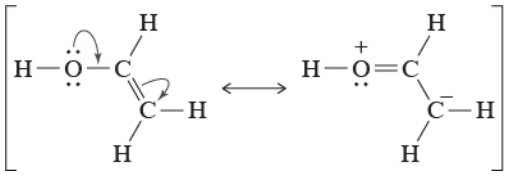
i. Answer:




ii. Answer:

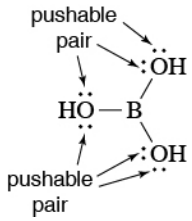



iii. Answer:

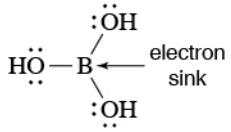


e.

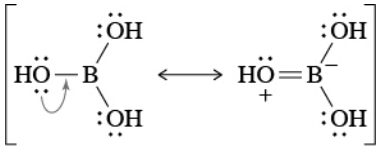
i. Answer:




ii. Answer:

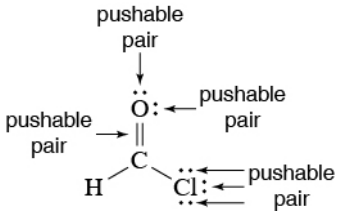



iii. Answer:

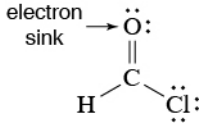


f.

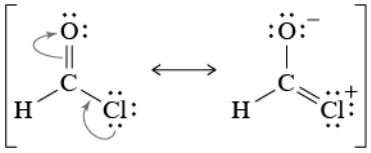
i. Answer:




ii. Answer:




iii. Answer:




**A2.50**

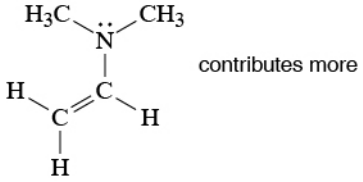
a.



i. Answer:

Neither resonance contributor actually exists. The only thing that exists is the resonance hybrid.

ii. Answer:




iii. Answer:

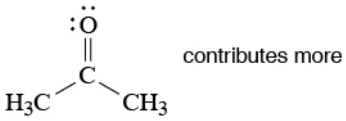
No formal charges.

b.

i. Answer:

Neither resonance contributor actually exists. The only thing that exists is the resonance hybrid.

ii. Answer:



iii. Answer:
No formal charges.

c.

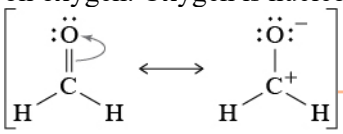
i. Answer:
Neither resonance contributor actually exists. The only thing that exists is the resonance hybrid.

ii. Answer:
Both contribute equally.

iii. Answer:
Both have the same number of bonds and formal charges on identical atoms.

**A2.51**

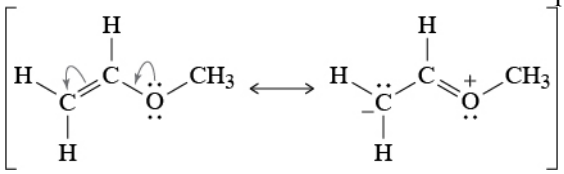
Answer:
H+ will add to O.
Fully Worked Solution:
Second best resonance contributor shows negative charge on oxygen. Oxygen is nucleophile.





**A2.52**

Answer:
Br+ will add to carbon on the left.
Fully Worked Solution:
Second best resonance contributor shows negative charge on carbon on left. Carbon on left is best nucleophile.



**A2.53**

a. Answer:
$sp^2$
Fully Worked Solution:
N has four electron domains; it looks like it should be $sp^3$ hybridized. But since it is involved in resonance, it must be $sp^2$ hybridized.

b. Answer:
$sp^2$
Fully Worked Solution:
N has three electron domains and so must be $sp^2$ hybridized.

**A2.54**

Answer:

Carboxylate: $sp^2$, alkoxide: $sp^3$, carboxylate more stable

Fully Worked Solution:

The carboxylate is resonance stabilized. The electrons are spread out over a larger volume; this makes the molecule more stable.

## END-OF-CHAPTER PROBLEMS

**P2.55**

a. Answer:
4

b. Answer:
6

c. Answer:
3

d. Answer:
7

e. Answer:
7



f. Answer:
5

g. Answer:
6

h. Answer:
7

i. Answer:
7

j. Answer:
3

k. Answer:
4

l. Answer:
1

**P2.56**

a. Answer:

b. Answer:

c. Answer:

d. Answer:

e. Answer:

f. Answer:

g. Answer:

h. Answer:

i. Answer:

j. Answer:



k. Answer:

l. Answer:

**P2.57**

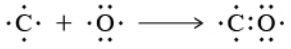
Answer:

N and P are in the same column of the periodic table and have the same number of valence shell electrons.

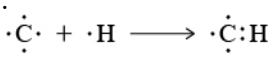
**P2.58**

a. Answer:

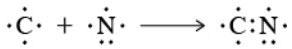
b. Answer:



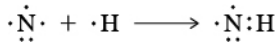
c. Answer:



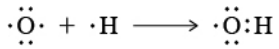
d. Answer:



e. Answer:



f. Answer:



**P2.59**

a. Answer:

O

Fully Worked Solution:

In general, the less electronegative element and/or the element that can make the most bonds will tend to be the central element for small molecules.

b. Answer:

C

Fully Worked Solution:

In general, the less electronegative element and/or the element that can make the most bonds will tend to be the central element for small molecules.

c. Answer:

N

Fully Worked Solution:



In general, the less electronegative element and/or the element that can make the most bonds will tend to be the central element for small molecules.

d. Answer:

C

Fully Worked Solution:

In general, the less electronegative element and/or the element that can make the most bonds will tend to be the central element for small molecules.

e. Answer:

C

Fully Worked Solution:

In general, the less electronegative element and/or the element that can make the most bonds will tend to be the central element for small molecules.

f. Answer:

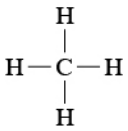
C

Fully Worked Solution:

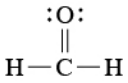
In general, the less electronegative element and/or the element that can make the most bonds will tend to be the central element for small molecules.

**P2.60**

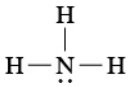
a. Answer:



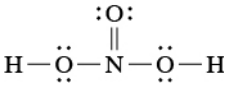
b. Answer:



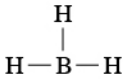
c. Answer:



d. Answer:



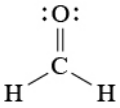
e. Answer:



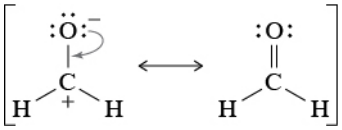
**P2.61**



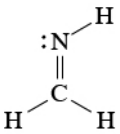
a. Answer:



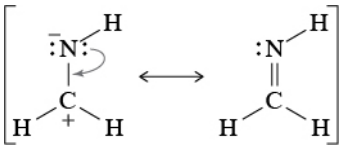
Fully Worked Solution:



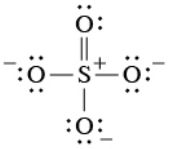
b. Answer:



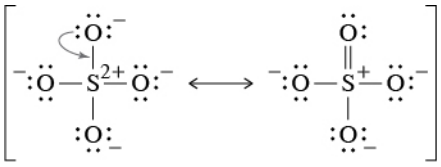
Fully Worked Solution:



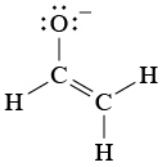
c. Answer:



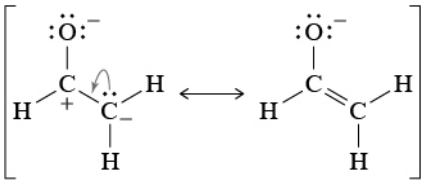
Fully Worked Solution:



d. Answer:

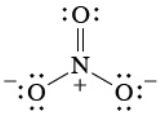


Fully Worked Solution:

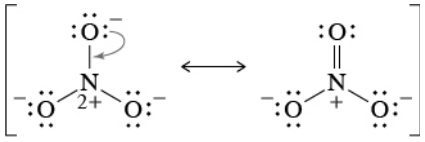


e. Answer:



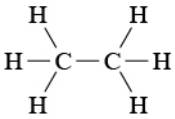


Fully Worked Solution:

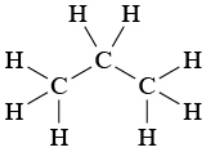


**P2.62**

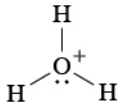
a. Answer:



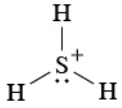
b. Answer:



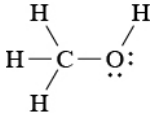
c. Answer:



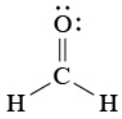
d. Answer:



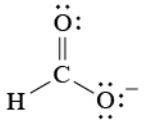
e. Answer:



f. Answer:

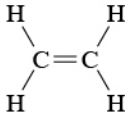


g. Answer:

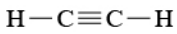




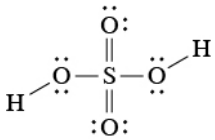
h. Answer:



i. Answer:

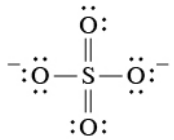


j. Answer:

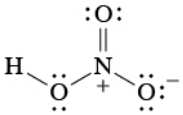


k. Answer:

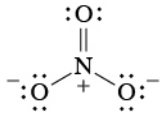
l. Answer:



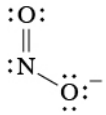
m. Answer:



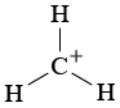
n. Answer:



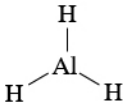
o. Answer:



p. Answer:

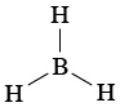


q. Answer:

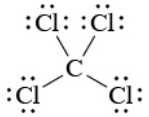




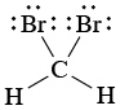
r. Answer:



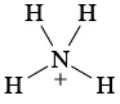
s. Answer:



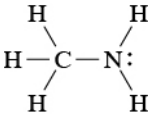
t. Answer:



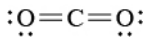
u. Answer:



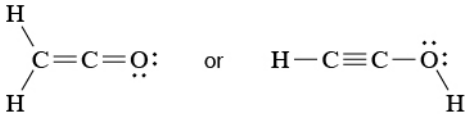
v. Answer:



w. Answer:

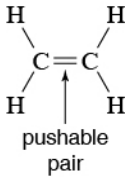


x. Answer:

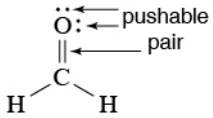



**P2.63**

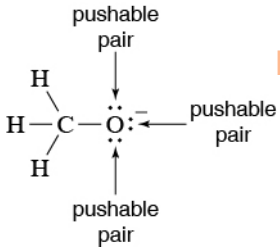
a. Answer:




b. Answer:

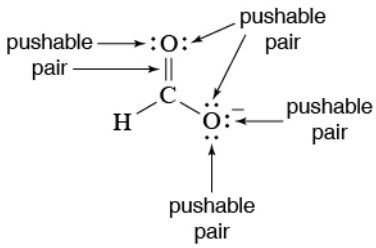



c. Answer:

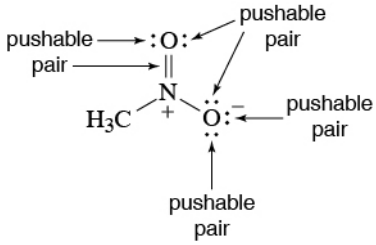





d. Answer:

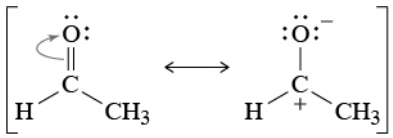



e. Answer:

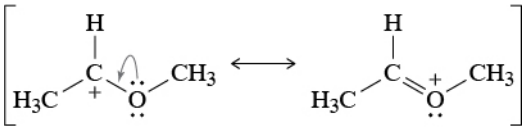


**P2.64**

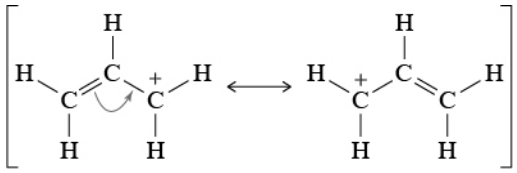
a. Answer:



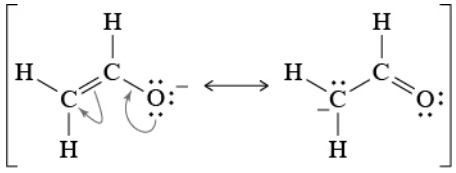
b. Answer:



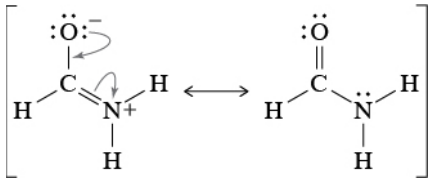
c. Answer:



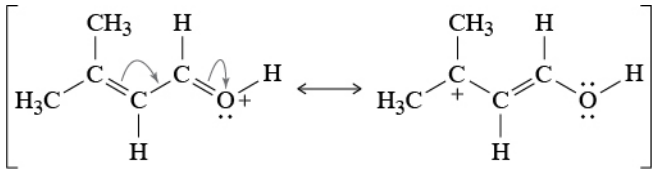
d. Answer:



e. Answer:

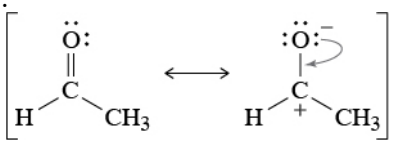


f. Answer:

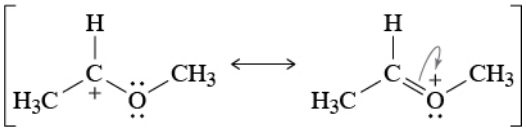


**P2.65**

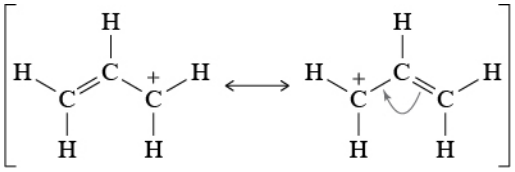
a. Answer:



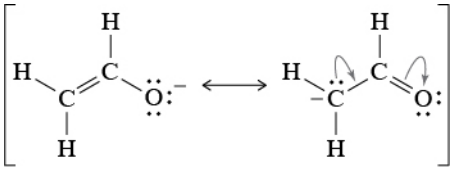
b. Answer:



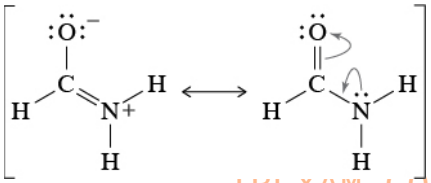
c. Answer:



d. Answer:

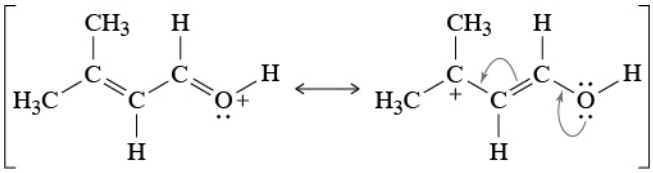


e. Answer:





f. Answer:

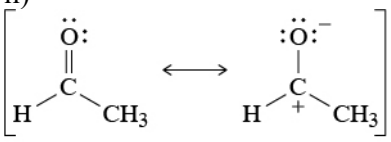


**P2.66**

a. Answer:

i) Neither structure actually exists. The only thing that exists is the resonance hybrid.

ii)



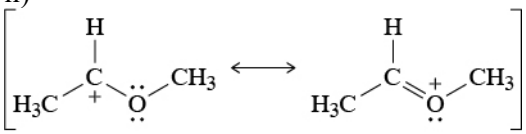
most contributing

(fewest formal charges)

b. Answer:

i) Neither structure actually exists. The only thing that exists is the resonance hybrid.

ii)



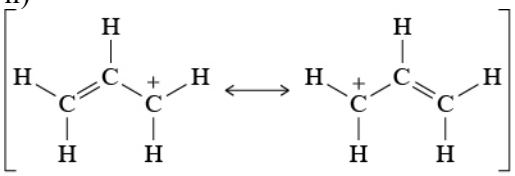
most contributing

(all atoms have a full octet)

c. Answer:

i) Neither structure actually exists. The only thing that exists is the resonance hybrid.

ii)



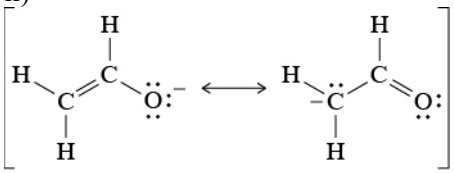
both contribute equally

(all have same number of formal charges/ electron deficient atoms, etc.)

d. Answer:

i) Neither structure actually exists. The only thing that exists is the resonance hybrid.

ii)



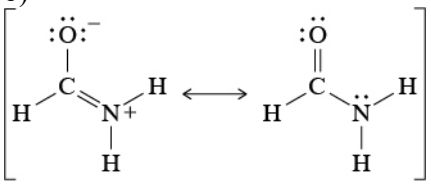
most contributing

(negative charge on most electronegative element)

e. Answer:

i) Neither structure actually exists. The only thing that exists is the resonance hybrid.

b)



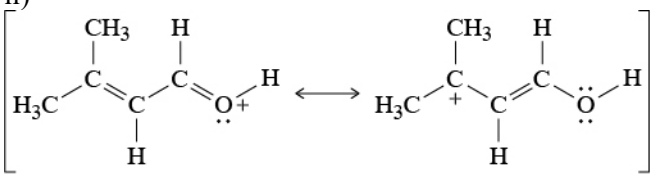
most contributing

(fewest formal charges)

f. Answer:

i) Neither structure actually exists. The only thing that exists is the resonance hybrid.

ii)

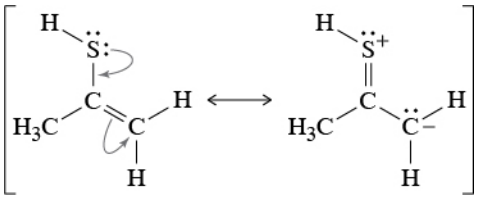


most contributing

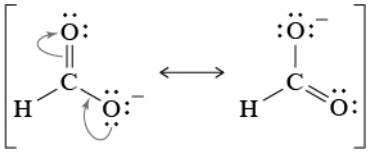
(all atoms have a full octet)

**P2.67**

a. Answer:

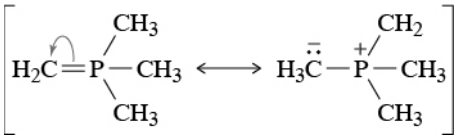


b. Answer:

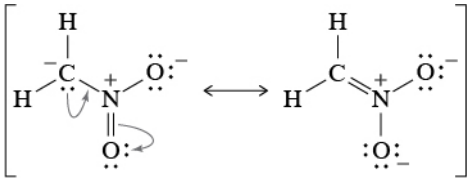




c. Answer:

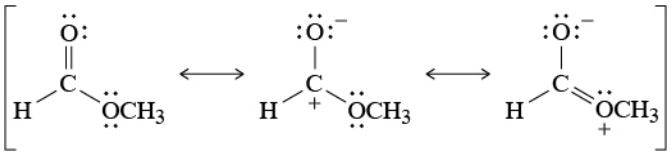


d. Answer:

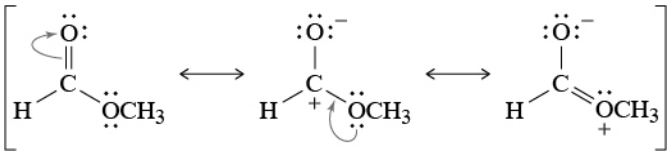


**P2.68**

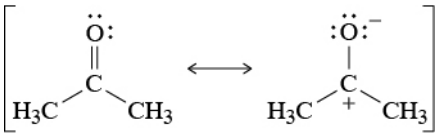
a. Answer:



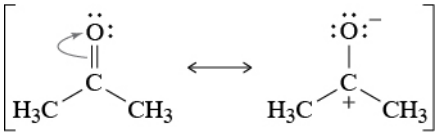
Fully Worked Solution:



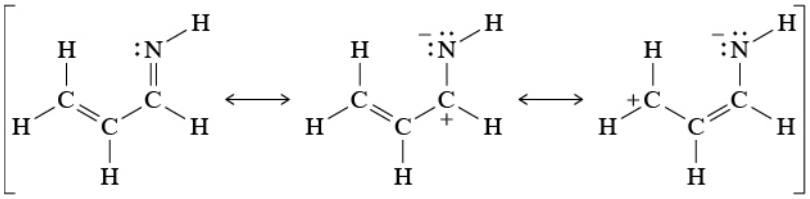
b. Answer:



Fully Worked Solution:



c. Answer:



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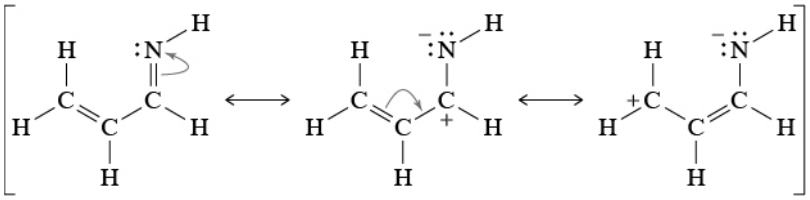
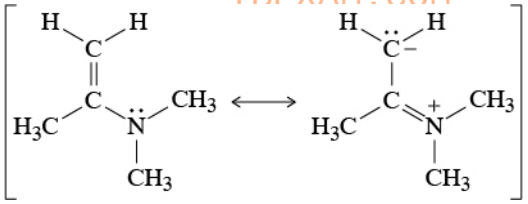
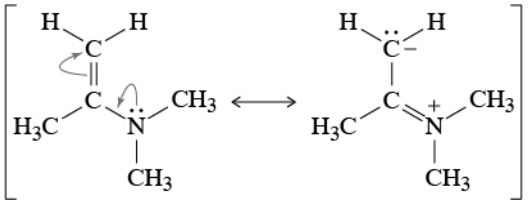


d. Answer:

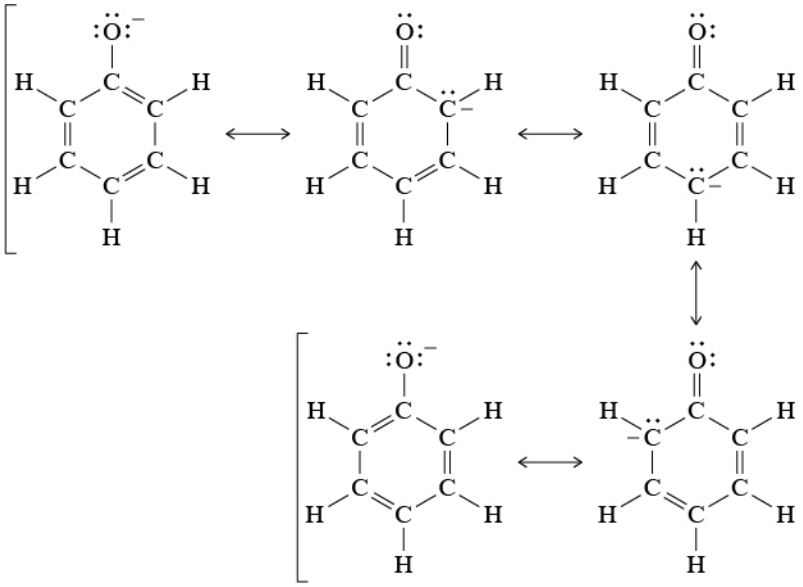




Fully Worked Solution:



e. Answer:



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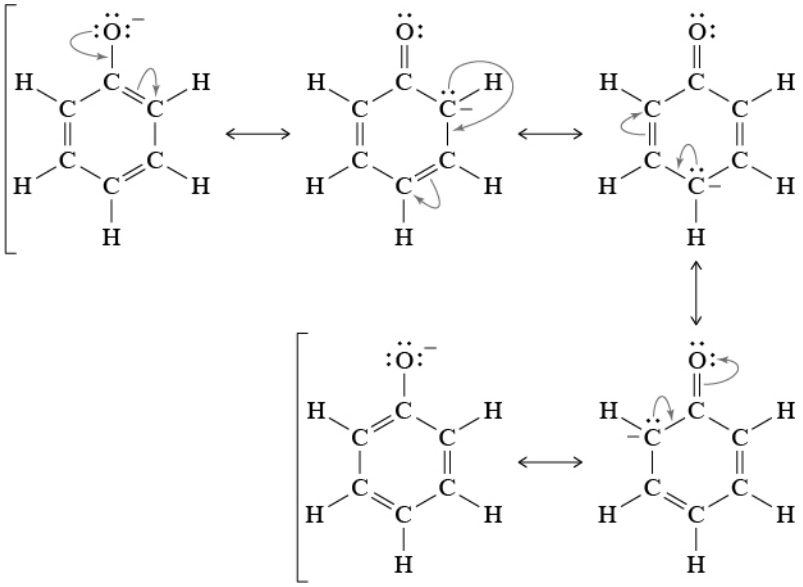
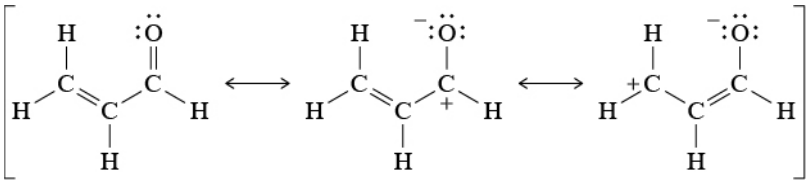
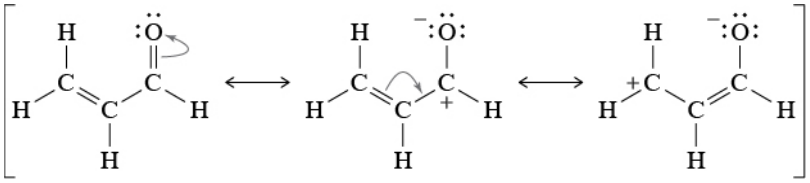


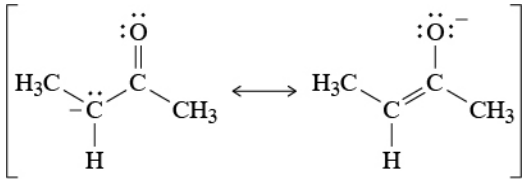
f. Answer:



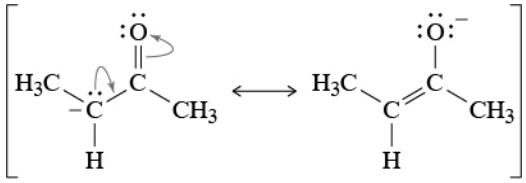
Fully Worked Solution:



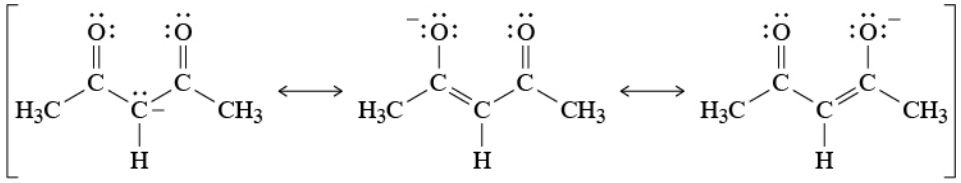
g. Answer:



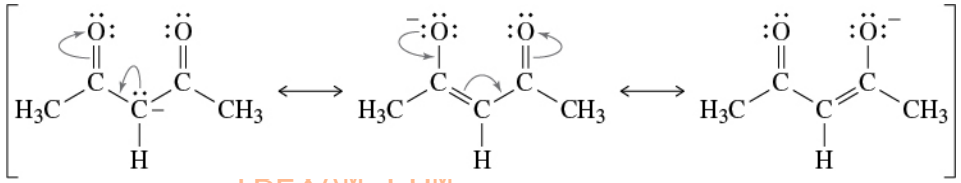
Fully Worked Solution:



h. Answer:

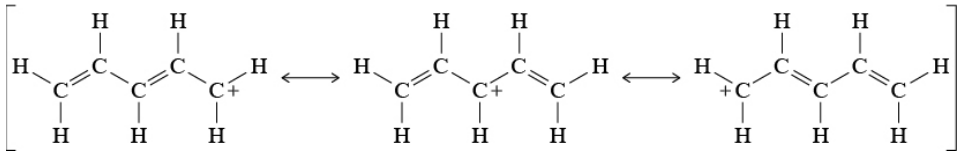


Fully Worked Solution:

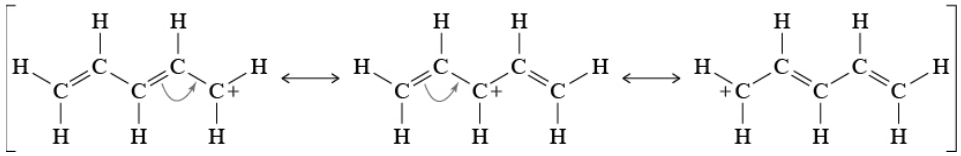




i. Answer:



Fully Worked Solution:



**P2.69**

a. Answer:

C: tetrahedral (both)

Fully Worked Solution:

C: four electron domains (four single bonds), therefore tetrahedral

b. Answer:

C: tetrahedral

O: tetrahedral

Fully Worked Solution:

C: four electron domains (four single bonds), therefore tetrahedral

O: four electron domains (two single bonds, two lone pairs), therefore tetrahedral

c. Answer:
C: trigonal planar
O: trigonal planar
Fully Worked Solution:
C: three electron domains (two single bonds, one double bond), therefore trigonal planar
O: three electron domains (one double bond, two lone pairs), therefore trigonal planar

d. Answer:
C: trigonal planar (both)
Fully Worked Solution:
C: three electron domains (two single bonds, one double bond), therefore trigonal planar

e. Answer:
Al: trigonal planar
Fully Worked Solution:
Al: three electron domains (three single bonds), therefore trigonal planar

f. Answer:
C: tetrahedral
Cl: tetrahedral (all)
Fully Worked Solution:
C: four electron domains (four single bonds), therefore tetrahedral
Cl: four electron domains (one single bond, three lone pairs), therefore tetrahedral



g. Answer:
C: linear
O: trigonal planar (both)
Fully Worked Solution:
C: two electron domains (two double bonds), therefore linear
O: three electron domains (one double bond, two lone pairs), therefore trigonal planar

**P2.70**

a. Answer:
C: $sp^3$ (both)
Fully Worked Solution:
C: four electron domains (four single bonds), therefore tetrahedral, therefore $sp^3$

b. Answer:
C: $sp^3$
O: $sp^3$
Fully Worked Solution:
C: four electron domains (four single bonds), therefore tetrahedral, therefore $sp^3$
O: four electron domains (two single bonds, two lone pairs), therefore tetrahedral, therefore $sp^3$

c. Answer:
C: $sp^2$
O: $sp^2$
Fully Worked Solution:
C: three electron domains (two single bonds, one double bond), therefore trigonal planar, therefore $sp^2$
O: three electron domains (one double bond, two lone pairs), therefore trigonal planar, therefore $sp^2$

d. Answer:
C: $sp^2$ (both)
Fully Worked Solution:
C: three electron domains (two single bonds, one double bond), therefore trigonal planar, therefore $sp^2$

e. Answer:
Al: $sp^2$
Fully Worked Solution:
Al: three electron domains (three single bonds), therefore trigonal planar, therefore $sp^2$

f. Answer:
C: $sp^3$
Cl: $sp^3$ (all)
Fully Worked Solution:
C: four electron domains (four single bonds), therefore tetrahedral, therefore $sp^3$
Cl: four electron domains (one single bond, three lone pairs), therefore tetrahedral, therefore $sp^3$

g. Answer:
C: sp
O: $sp^2$
Fully Worked Solution:
C: two electron domains (two double bonds), therefore linear, therefore sp
O: three electron domains (one double bond, two lone pairs), therefore trigonal planar, therefore $sp^2$

**P2.71**

Answer:
four $sp^3$ orbitals, zero p orbitals

**P2.72**

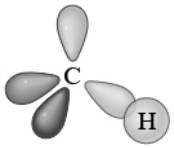
Answer:
three $sp^2$ orbitals, one p orbital

**P2.73**

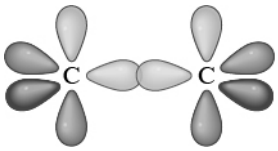
Answer:
two sp orbitals, two p orbitals

**P2.74**

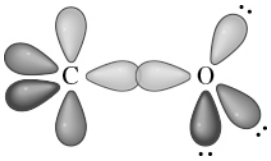
a. Answer:



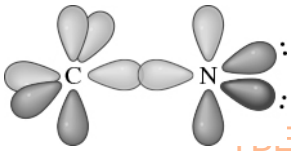

b. Answer:




c. Answer:



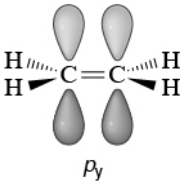

d. Answer:



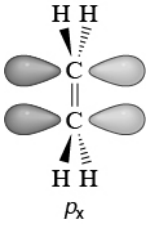



**P2.75**

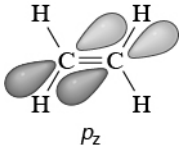
a. Answer:



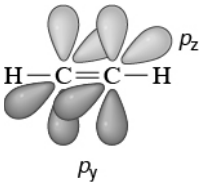

b. Answer:



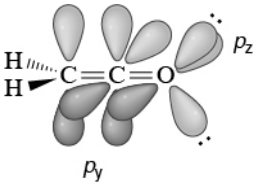

c. Answer:



d. Answer:

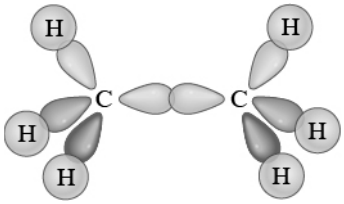



e. Answer:

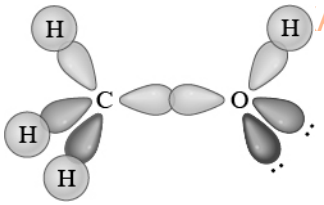



**P2.76**

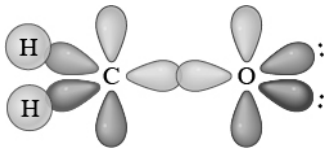
a. Answer:



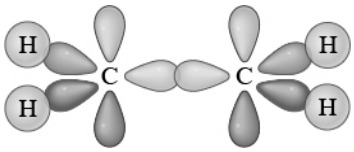

b. Answer:



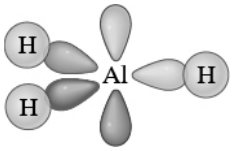

c. Answer:



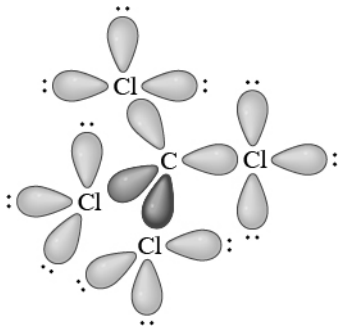

d. Answer:



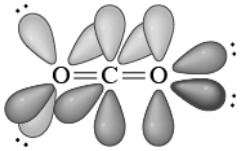

e. Answer:



f. Answer:

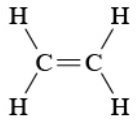


g. Answer:



**P2.77**

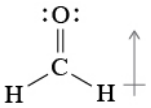
a. Answer:



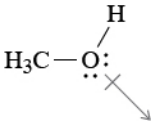
no net dipole



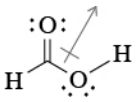
b. Answer:



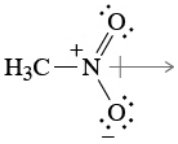
c. Answer:



d. Answer:



e. Answer:



**P2.78**

Answer:

$CO_2$ is linear, $SO_2$ is trigonal planar.

Fully Worked Solution:

Carbon dioxide is a linear molecule, and the polar bonds are 180° opposed. The polar bonds cancel out, resulting in no net dipole.

Sulfur dioxide is a trigonal planar molecule, and the polar bonds are ~120° from each other. The dipoles corresponding to the two polar bonds do not cancel out in this case, so their combination results in a net dipole on sulfur dioxide.

**P2.79**

Answer:

Ethane only contains σ-bonds, which can freely rotate. Ethene contains a π-bond, which cannot freely rotate.

Fully Worked Solution:

The carbon atoms in ethane are connected through a σ-bond. The coaxial overlap of the orbitals means the bond can rotate and the orbitals are still fully overlapped.

The carbon atoms in ethene are connected through a σ- and a π-bond. The off-axial overlap of the p orbitals comprising the π-bond means that as the π-bond rotates, the p orbitals no longer overlap. To rotate about the π-bond in ethene would require breaking the π-bond, necessitating a high amount of energy.

**P2.80**

Answer:

The carbon atoms in ethane are $sp^3$ hybridized, while the carbon atoms in ethene are $sp^2$ hybridized.



Fully Worked Solution:

The carbon atoms in ethene are $sp^2$ hybridized. An $sp^2$-hybridized atom is more electronegative than an $sp^3$-hybridized atom. The electrons are held more tightly to the nucleus, and the sigma-bonds are shorter as a result.

**P2.81**

Answer:

All carbon atoms in the allyl cation are $sp^2$ hybridized, and the allyl cation can engage in resonance, making all bond lengths equal.

Fully Worked Solution:

The carbon atoms in the allyl cation are all $sp^2$ hybridized. An $sp^2$-hybridized atom is more electronegative than an $sp^3$-hybridized atom. The electrons are held more tightly to the nucleus, and the sigma-bonds are shorter as a result.

Additionally for the allyl cation, the molecule is resonance stabilized. The true structure of the resonance hybrid has a partial double bond between all carbon atoms. The partial double-bond character shortens the bond length.

**P2.82**

Answer:

The electrons would go into the empty, unhybridized p orbital on the carbon atom.

**P2.83**

Answer:

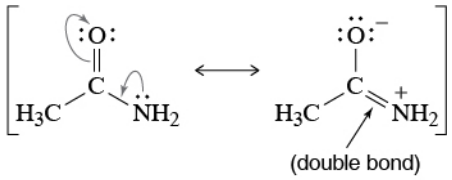
The oxygen has a complete octet and all orbitals are full. There is nowhere for a lone pair of electrons to add.

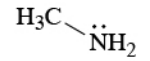
**P2.84**

Answer:

The lone pair of electrons on the nitrogen atom in the amide can be stabilized by resonance. The resonance stabilization makes the C–N bond of the amide a partial double bond. The significant double-bond character of the C–N bond in the amide makes the bond stronger than the nonresonance-stabilized C–N s-bond in the amine. As a consequence of the double-bond character, rotation about the C–N bond in the amide is considerably restricted.

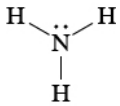
Fully Worked Solution:



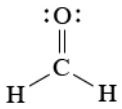




**P2.85**

a. Answer:

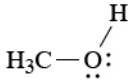


b. Answer:

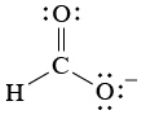




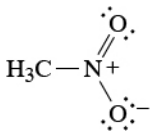
c. Answer:



d. Answer:



e. Answer:



**P2.86**

Answer:

The $CH_3^-$ anion has a lone pair of electrons on carbon that can be donated to an electron acceptor (a Lewis acid) to form a new bond.

**P2.87**

Answer:

The boron does not have a lone pair of electrons that can be donated.