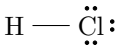
1 Bonding and Molecular Structure

10/14: 1. Write a Lewis structure for each of the following compounds and indicate whether the bonding is nonpolar covalent, polar covalent, or ionic. Assume that a difference in electronegativity greater than 1.7 corresponds to a bond that is considered predominantly ionic.

(a) HCl.

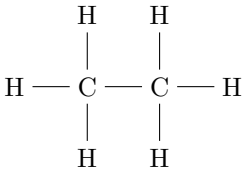
Answer.



Polar covalent. □

(b) C_2H_6.

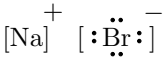
Answer.



Nonpolar covalent. □

(c) NaBr.

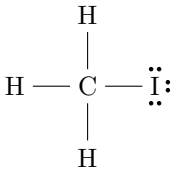
Answer.



Ionic. □

(d) CH_3I.

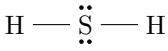
Answer.



C–H is nonpolar covalent; C–I is nonpolar covalent. □

(e) H_2S.

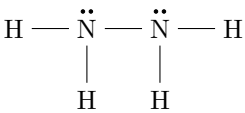
Answer.



Nonpolar covalent. □

(f) N_2H_4.

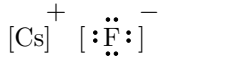
Answer.



N–H is polar covalent; N–N is nonpolar covalent. □

(g) CsF.

Answer.



Ionic. □

2. For the following covalent bonds...

   (a) Use the symbols δ^+ and δ^- to indicate the direction of polarity (if any).

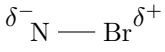
      (i) C–F.

      Answer.

      □

      (ii) N–Br.

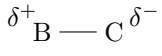
      Answer.



      □

      (iii) B–C.

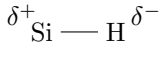
      Answer.



      □

      (iv) Si–H.

      Answer.



      □

   (b) Rank the following covalent bonds in order of *increasing* polarity.

      (i) C–H, O–H, N–H.

      Answer.

$$\text{C–H} < \text{N–H} < \text{O–H}$$

      □

      (ii) C–N, C–O, B–O.

      Answer.

$$\text{C–N} < \text{C–O} < \text{B–O}$$

      □

      (iii) C–P, C–S, C–N.

      Answer.

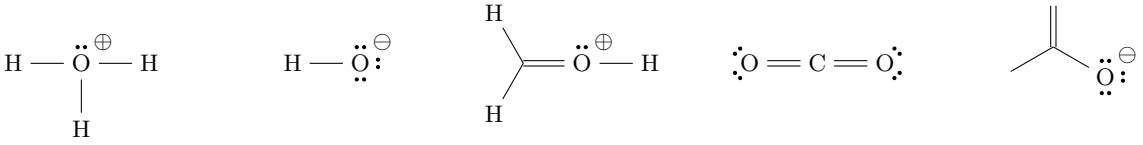
$$\text{C–S} < \text{C–P} < \text{C–N}$$

      □

3. Formal charge.

   (a) Consider the oxygen atom in the structures below and determine if it has a formal charge. If so, label it on the molecule.

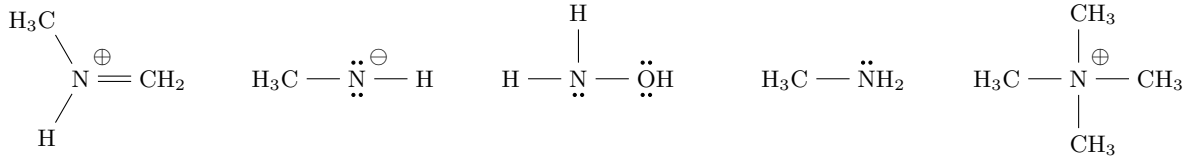
      Answer.



      □

(b) Consider the nitrogen atom in the structures below and determine if it has a formal charge. If so, label it on the molecule.

Answer.

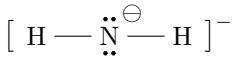


□

4. Draw Lewis structures and resonance structures (if any) that satisfy the octet rule for each of the following ions with all valence electrons and formal charges clearly noted.

(a) NH_2^-.

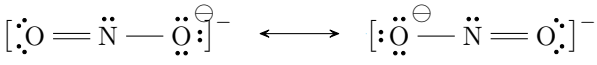
Answer.



□

(b) NO_2^-.

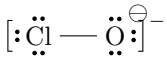
Answer.



□

(c) ClO^-.

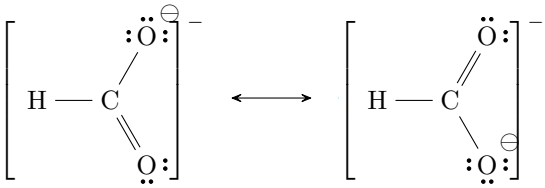
Answer.



□

(d) $HCOO^-$.

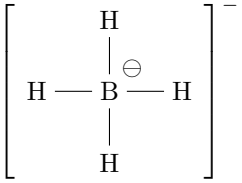
Answer.



□

(e) BH_4^-.

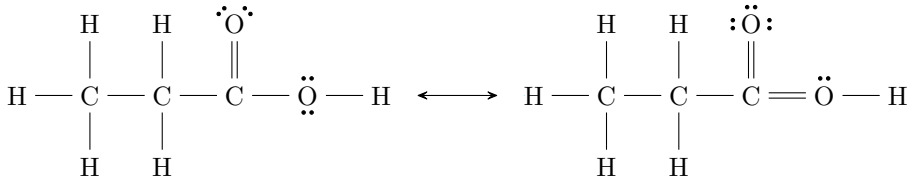
Answer.



□

(f) $CH_3CH_2CO_2H$.

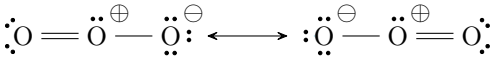
Answer.



□

(g) O_3.

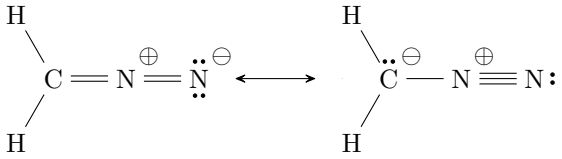
Answer.



□

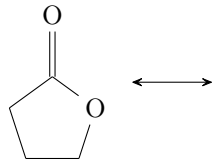
(h) CH_2N_2.

Answer.

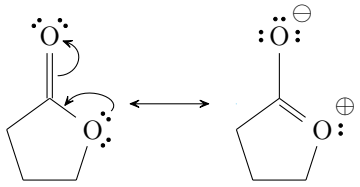


□

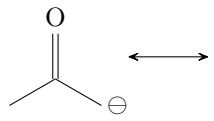
5. For the following chemical species, draw a resonance structure that satisfies the octet rule. Indicate whether you expect it to be a major or minor contributor to the actual structure of the species and briefly state your reasoning. Use curved arrows to clearly show how the structure converts to another structure (if any).

(a) 

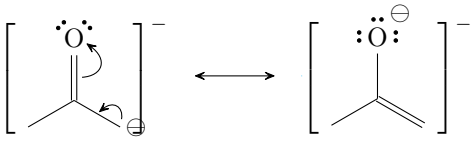
Answer.



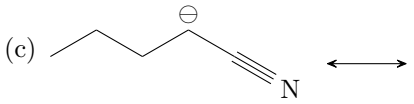
The right structure will be a minor contributor because it has formal charges while the original one doesn't. Additionally, there is a positive formal charge on oxygen. □

(b) 

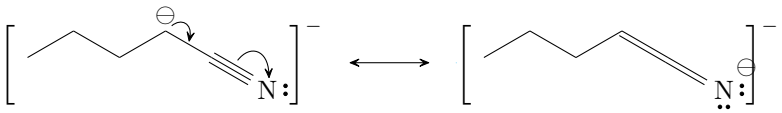
Answer.



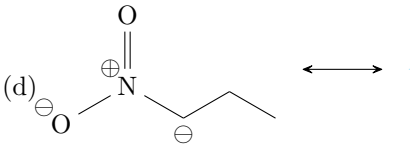
The right structure will be a major contributor because the negative formal charge is on the more electronegative atom. □

(c) 

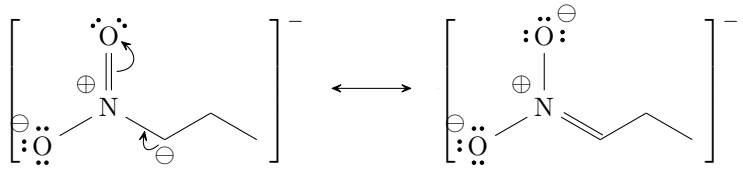
Answer.



The right structure will be a major contributor because the negtive formal charge is on the more electronegative atom. □

(d) 

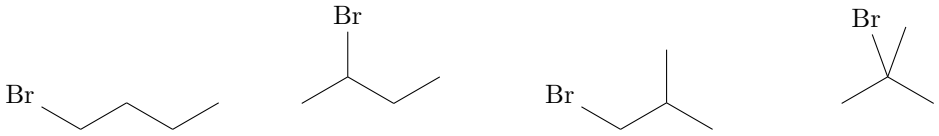
Answer.



The right structure will be a major contributor because the negative formal charges are on the more electronegative atoms. □

6. Draw all four constitutional isomers of C_4H_9Br using bond-line formulas.

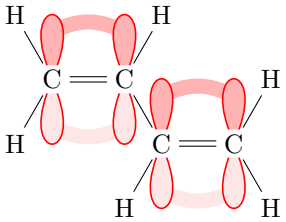
Answer. □



7. For each of the following condensed structures: (i) draw the corresponding Lewis structures, (ii) provide the hybridization to all carbon atoms, and (iii) draw individual p orbitals for all the π bonds with directions clearly indicated.

   (a) $CH_2CHCHCH_2$.

   Answer. (i) / (iii):

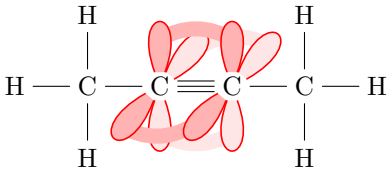


   (ii): Every carbon atom is sp^2.

□

(b) CH_3CCCH_3.

Answer. (i) / (iii):

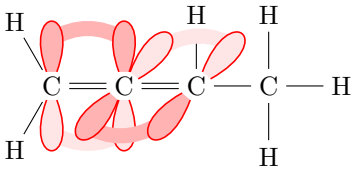


(ii): The outer two carbon atoms are sp^3. The inner two carbon atoms are sp.

□

(c) CH_2CCHCH_3.

Answer. (i) / (iii):



(ii): The first and third carbon atoms from the left are sp^2. The second carbon atom from the left is sp. The right carbon atom is sp^3.

□