ANSWER KEY.

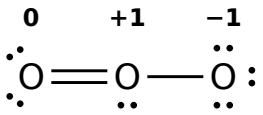
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2.6 Resonance and Formal Charge

AP Chemistry | ANSWER KEY

Formal charge: FC = V − N − ½B (valence electrons − nonbonding electrons − half the bonding electrons). Show all lone pairs.

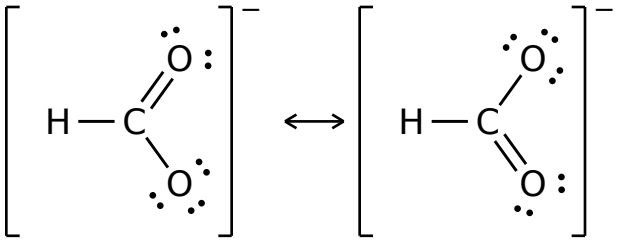
1. One Lewis structure for ozone, O_3, is shown. Calculate the formal charge on each oxygen atom, then check that they add up to the overall charge.



Left O: 6 − 4 − 2 = 0. Center O: 6 − 2 − 3 = +1. Right O: 6 − 6 − 1 = −1.

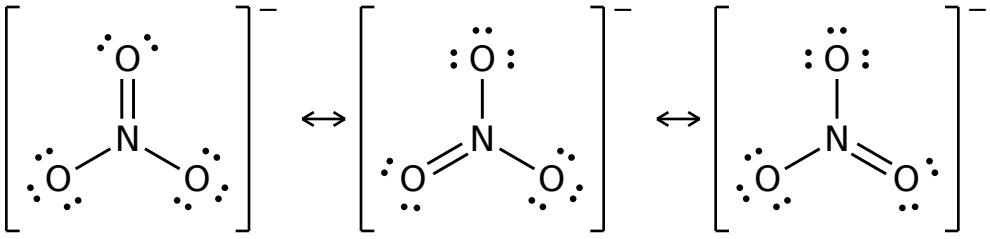
Sum: 0 + 1 + (−1) = 0, which matches the neutral molecule.

2. Draw both resonance structures for the formate ion, HCO_2^- (C is central and bonded to H and both O atoms). What is the average C–O bond order?



18 valence electrons. Two equivalent structures; average C–O bond order = 3 bonds / 2 locations = 1.5

3. Draw all resonance structures for the nitrate ion, NO_3^-. All three N–O bonds in nitrate have the same length. Explain why, and give the average bond order.

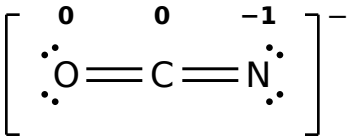


The real ion is a resonance hybrid of three equivalent structures, so every N–O bond is the same. Average bond order = 4 bonds / 3 locations = 1.33

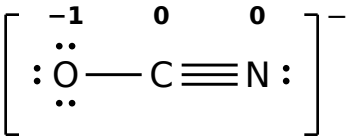
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4. Three possible Lewis structures for the cyanate ion, OCN^-, are shown. Assign formal charges to every atom, then choose the best structure and justify your choice.

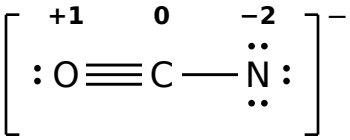
A



B



C



B is best. A and B both have small formal charges (0 and −1), but B puts the −1 on O, the most electronegative atom. C has charges of +1 and −2, which are too large.

5. Rank the N–O bonds in NO^+, NO_2^-, and NO_3^- from **shortest** to **longest**. Justify your ranking with bond order.

Bond orders: NO^+ = 3 (triple bond), NO_2^- = 1.5, NO_3^- = 1.33

NO^+ < NO_2^- < NO_3^-. A higher bond order gives a shorter bond.

6. Chlorine dioxide, ClO_2, is used to treat drinking water. Explain why no Lewis structure of ClO_2 can have every electron paired.

ClO_2 has 7 + 2(6) = 19 valence electrons. An odd number of electrons cannot all be in pairs, so one electron is unpaired (a free radical). This is a limit of the Lewis model.

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