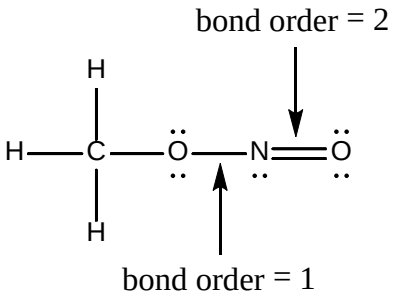
Answers to Exercise 8.6
Bond Order

1. What are the bond orders for the N-O bonds in the species shown below?

(a) 3

(b) 2

(c)



(d) 1½

(e) 1⅓

In (c), there is only one valid resonance structure. The bond between N and the central O is a single bond while the bond between N and the terminal O is a double bond.

In (d) and (e), the ions exist as averages of the resonance structures shown.

As such, in (d), the N-O bonds are both "halfway between a single bond and a double bond".

Similarly, in (e), the N-O bonds are all "about one third double bond and two thirds single bond".

When a species exists as an average of two degenerate (equivalent) resonance structures, bond order can be calculated by taking an average of the bond orders observed for that bond in each resonance structure.

As such, for (d), each N-O bond has a bond order of $\frac{2+1}{2} = \frac{3}{2} = 1\frac{1}{2}$

For (e), each N-O bond has a bond order of $\frac{2+1+1}{3} = \frac{4}{3} = 1\frac{1}{3}$

2.

(a) The resonance structures are not degenerate so they do not contribute equally to the ion's structure. The ion exists as a weighted average of these two resonance structures – with the better resonance structure contributing more to the average.

(b) Based on these two resonance structures, the C-N bond order must be between 2 and 3. Since the resonance structure on the left is better than the one on the right, the C-N bond order will be closer to 3 than to 2. As such, we can conclude that the C-N bond order is between 2.5 and 3 for this ion.