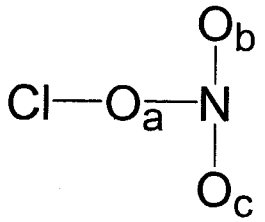
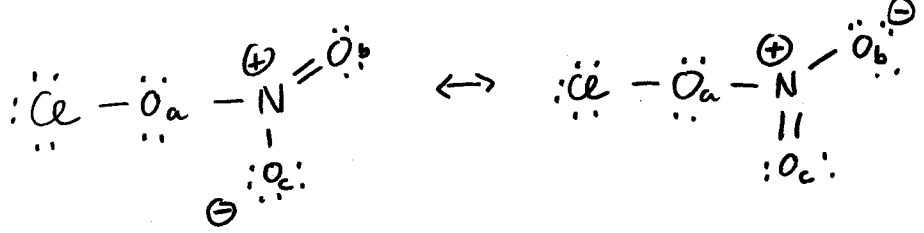
6. A key player in stratospheric ozone depletion is chlorine nitrate, $ClONO_2$. Its connectivity (that is, the location of its sigma bonds) is known to be the following:




30 valence e⁻ => 15 pairs

(a) (6 points) Draw the <u>two</u> best resonance structures for $ClONO_2$. (They will be equivalent.) Be sure to show <u>all</u> valence electrons, and label all non-zero formal charges. Keep the oxygens labeled as $O_a$, $O_b$, and $O_c$ for the purpose of further discussion.



-2 formal charge error
-1 missing a lone pair
-3 octet-deficient O or N
-4 hypervalent O or N

(b) (3 points) Write down the hybridization for the following atoms in chlorine nitrate. You need not justify your answers beyond what you have drawn for part (a).

Cl $sp^3$ $O_a$ $sp^3$ N $sp^2$

Cl: no need to hybridize)

(c) (4 points) Experimentally, one of the $ClONO_2$ bond angles is known to be 133°. Which angle would you predict it to be? (Circle your choice.)

(i) θ(Cl-$O_a$-N) (ii) θ($O_a$-N-$O_b$) (iii) θ($O_a$-N-$O_c$) (iv) θ($O_b$-N-$O_c$)

(d) (6 points) Justify your answer to part (c) by using the concepts of VSEPR theory. Be sure to discuss both what is expected ideally, and deviations from that ideal.

Since the N is $sp^2$-hybridized, we'd expect the 3 angles about it to be ~120°. (This is unlike the Cl-$O_a$-N angle, which should be ~109.5°) Given that the 2 resonance structures are equivalent, we can assign a bond order of 1.5 to both N-$O_b$ and N-$O_c$. These partial double bonds will repel each other the most, which will lead to a $O_b$-N-$O_c$ angle of > 120°.

grading rubrics next page