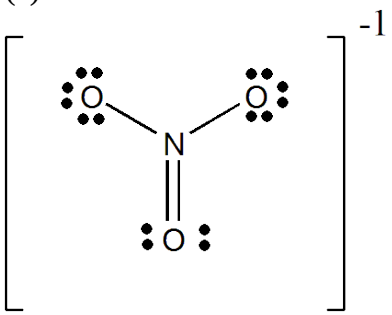
Formula Charge = {Group Number – (number nonbonding electrons + number of bonds)}

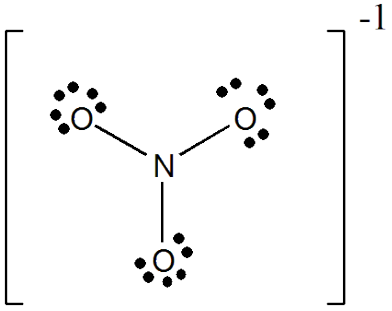
1(a) Nitrate ion



Atom	Group No.	Non-bonding Electrons	Bonds	Formal Charge
N	5	0	4	**+1**
O	1 (6)	(1)(4) = 4	2	**0**
O	2(6) = 12	(2)(6) = 12	2(1) = 2	**-2**
Total Formal Charge				**-1**

This means that the nitrogen atom has a formal charge of +1, and that <u>each</u> of 2 oxygen atoms with single bonds to nitrogen has an formal charge of -1 (total for oxygen = -2).

1(b)



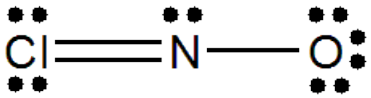
Atom	Group No.	Non-bonding Electrons	Bonds	Formal Charge
N	5	0	3	**+2**
O	6	(3)(6) = 18	3(1) = 3	**-3**
Total Formal Charge				**-1**

This means that the nitrogen atom has a formal charge of +2, and that <u>each</u> of the 3 oxygen atoms has an formal charge of -1 (total for oxygen = -3).

Note that the total formal charge on the nitrate ion is equal to the actual charge on the ion (-1).

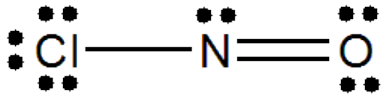
Because the formal charges on the atoms are larger on structure 1(b), the better Lewis dot structure for nitrate ion is 1(a).

2 (a) nitrosyl chloride(NOCl)



Atom	Group No.	Non-bonding Electrons	Bonds	Formal Charge
N	5	2	3	**0**
O	6	6	1	**-1**
Cl	7	4	2	**+1**
Total Formal Charge				**0**

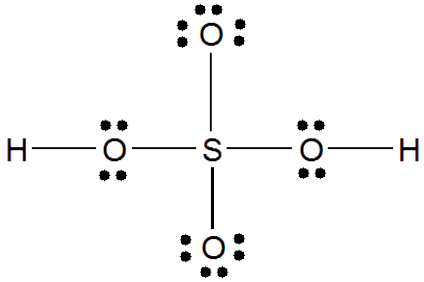
2(b)



Atom	Group No.	Non-bonding Electrons	Bonds	Formal Charge
N	5	2	3	**0**
O	6	4	2	**0**
Cl	7	6	1	**0**
Total Formal Charge				**0**

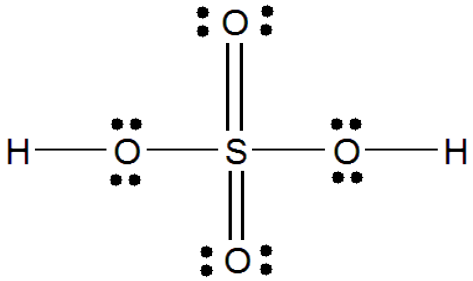
Both Lewis structures satisfy the octet rule. Lewis structure 2(b) is preferable, because there is no positive charge on Cl, which is a very electronegative atom and there are no formal charges on any of the atoms (formal charges are minimized).

3(a) Sulfuric Acid



Atom	Group No.	Non-bonding Electrons	Bonds	Formal Charge
S	6	0	4	**+2**
H	(2)1	(2)0	(2)1	**0**
O	(2)6	(2)4	(2)2	**0**
O	(2)6	(2)(6)	(2)(1)	**-2**
Total Formal Charge				**0**

3(b)

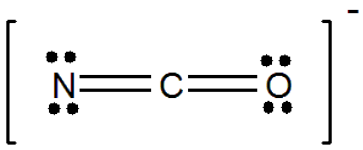


Atom	Group No.	Non-bonding Electrons	Bonds	Formal Charge
S	6	0	6	**0**
H	(2)1	(2)0	(2)1	**0**
O	(2)6	(2)4	(2)2	**0**
O	(2)6	(2)(4)	(2)(2)	**0**
Total Formal Charge				**0**

Sulfur can expand its valence shell and can accommodate more than 4 bonds. Lewis structure 2(b) is preferable, because there are no formal charges on any of the atoms.

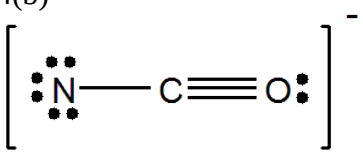
4(a) Cyanate ion (NCO^-)

The number of valence electrons is 16 – **don't forget the extra electron from the minus one (-1) charge.** There are 3 possible Lewis dot structures, which obey the octet rule.



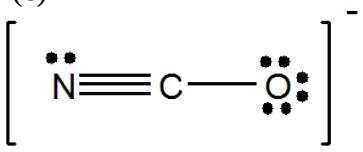
Atom	Group No.	Non-bonding Electrons	Bonds	Formal Charge
N	5	4	2	**-1**
C	4	0	4	**0**
O	6	4	2	**0**
Total Formal Charge				**-1**

4(b)



Atom	Group No.	Non-bonding Electrons	Bonds	Formal Charge
N	5	6	1	**-2**
C	4	0	4	**0**
O	6	2	3	**+1**
Total Formal Charge				**-1**

4(c)

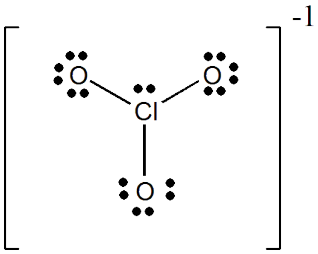


Atom	Group No.	Non-bonding Electrons	Bonds	Formal Charge
N	5	2	3	**0**
C	4	0	4	**0**
O	6	6	1	**-1**
Total Formal Charge				**-1**

Structure 4(a) has a formal charge of -1 on N, when oxygen is the most electronegative atom. Structure 4(b) has a formal charge of -2 on N and a positive one (+1) charge on oxygen, again with oxygen being the most electronegative atom. The negative charge should reside on the most electronegative atom, as in structure 4(c). Therefore, Lewis dot structure 4(c) is the most reasonable structure.

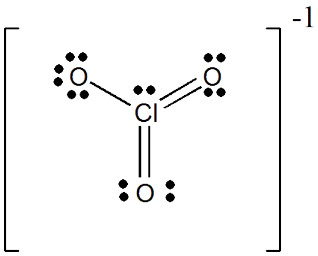
5(a) chlorate ion (ClO_3^-)

The number of valence electrons is 26. Here are 2 possible Lewis dot structures.



Atom	Group No.	Non-bonding Electrons	Bonds	Formal Charge
Cl	7	2	3	**+2**
O	(3)6	(3)6	(3)1	**-3**
Total Formal Charge				**-1**

5(b)



Atom	Group No.	Non-bonding Electrons	Bonds	Formal Charge
Cl	7	2	5	**0**
O (=)	(2)6	(2)4	(2)2	**0**
O (—)	6	6	1	**-1**
Total Formal Charge				**-1**

Structure 5(a) does obey the octet rule, but places a formal positive charge on a relatively electronegative atom (Cl) and has larger formal charges across all atoms than structure 5(b). Structure 5(b) does not obey the octet rule, but chlorine is in Period 3 (row 3) of the periodic table and can accommodate an expanded valence shell. Additionally, structure 5(b) minimizes the formal charges on all the atoms. Therefore, structure 5(b) is the most reasonable Lewis structure.

Note that structure 5(b) has 3 resonance structures. This means that each Cl-O bond exhibits the same partial double bond character. The evidence for this is the bond length for all three bonds is the identical and is in-between the length of a single Cl-O bond and a double Cl-O bond.