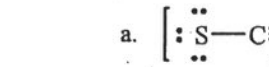
$$FC = V - (L + \tfrac{1}{2}S)$$

1. Below are three possible structures for the thiocyanate ion. Using principles of formal charge, determine which of the structures the actual species will more closely resemble. Explain how you used the principles of formal charge to select the preferred structure and eliminate the others. (In other words, tell what is favorable and what is unfavorable about each structure.)

a. 

b.

c.

	a.	b.	c.
S	$6-(6+1)=-1$	$6-(2+3)=1$	$6-(4+2)=0$
C	$4-(0+4)=0$	$4-(0+4)=0$	$4-(0+4)=0$
N	$5-(2+3)=0$	$5-(6+1)=-2$	$5-(4+2)=-1$

↓

a.
- ✓ FC do add up to −1
- X most (−) FC is not on most EN atom

b.
- ✓ FC do add up to −1
- ✓ most (−) FC is on most EN atom
- X Individual FC are larger (farther from zero)

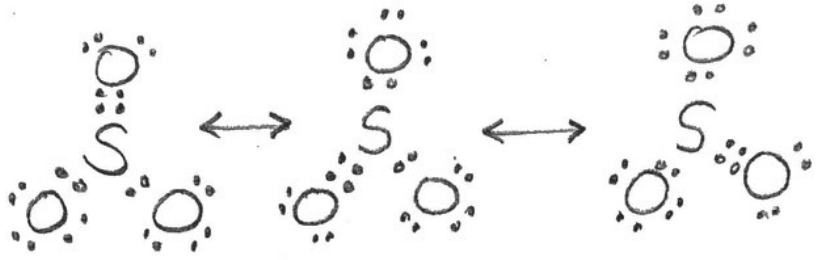
c.
- ✓ FC do add up to −1
- ✓ most (−) FC is on most EN atom → is Nitrogen
- ✓ Individual FC are closer to zero.

2. a. **Use Needs, Available, Shared (show work) to draw Lewis structures for sulfur trioxide, the sulfite ion, and sulfur dioxide. Include any resonance structures.**

SO_3^{2-}

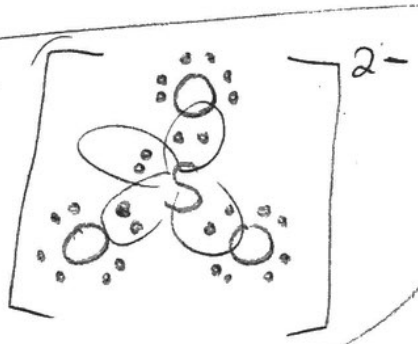
SO_3

N 32
A -24
S 8
NS 16



SO_3^{2-}

N 32
A -26
S 6
NS 20



SO_2

N 24
A -18
S 6
NS 12

(3) b. **Compare the relative lengths of the sulfur-oxygen bonds in the three molecules.**

SO_3^{2-} → longest, all single bonds

SO_3 → middle, average of 2 singles & 1 double

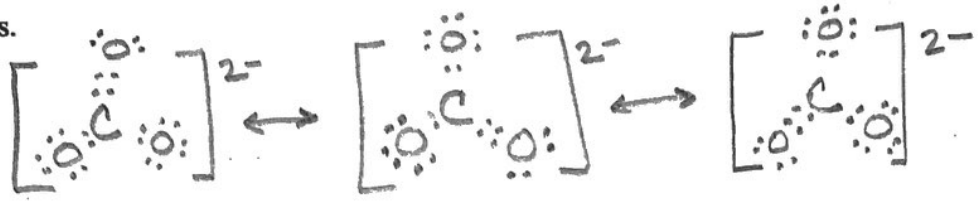
SO_2 → shortest, average of 1 single & 1 double

3. The carbonate ion, CO_3^{2-}, is formed when carbon dioxide reacts with slightly basic cold water.

a. Draw the Lewis structure for the carbonate ion and carbon dioxide. Include any resonance structures.

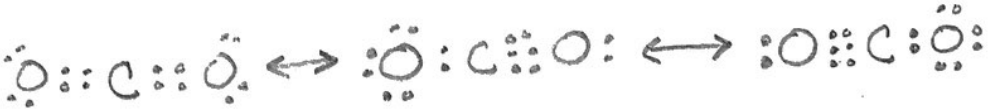
CO_3^{2-}

A = 24



CO_2

A = 16



b. Describe the relative bond energy of the three C – O bonds in the carbonate ion.

All of the bonds in CO_3^{2-} have the same bond energy. This is due to RESONANCE. The bond energy will be closer to C–O than C=O.

c. How does the bond energy of the C – O bonds in carbon dioxide compare to the bond energy in carbonate?

Bonds in CO_2 have greater bond energy than the bonds in CO_3^{2-}. CO_2 bonds are stronger and shorter than CO_3^{2-} bonds because they are an average of one single and one double bond while CO_3^{2-} bonds are an average of 2 singles and one double bond.

4. NO_2^+

N	24
A	16
S	8
NS	8

N $5-(0+4)=+1$
$=O$ $6-(4+2)=0$

N $5-(0+4)=1$
$-O$ $6-(2+3)=1$ ⇒ same
$\equiv O$ $6-(6+1)=-1$

FC add up to +1	✓	✓
(-) FC is on most EN atom	✓	✓/X?
No adjacent atoms have same FC	✓	X
Individual FC are close to zero	✓	X

5. A.) Write the balanced equation for the formation of one mole of sodium oxide from its elements.

$$2Na_{(s)} + \tfrac{1}{2}O_{2(g)} \rightarrow Na_2O_{(s)}$$

B.) Use the energies below to calculate **the lattice energy of sodium oxide.** In the table below, write an equation for each reaction step in the process and give the associated energy change. **Give the appropriate sign for the energy change.**

Bond energy for $O_2(g)$ = 495 kJ/mole

First electron affinity of O(g) = -142 kJ/mole

First ionization energy of Na(g) = 495 kJ/mole

Second electron affinity of O(g) = +844 kJ/mole

Enthalpy of sublimation of Na(s) = 109 kJ/mole

Enthalpy of formation of Na_2O = -416 kJ/mole

Reaction	Energy Change (kJ)
1. $2Na_{(s)} \rightarrow 2Na_{(g)}$	$(109)2 = 218$ kJ
2. $2Na \rightarrow 2Na^+_{(g)} + 2e^-$	$(495)2 = 990$ kJ
3. $\tfrac{1}{2}O_{2(g)} \rightarrow O_{(g)}$	$(495)\tfrac{1}{2} = 247.5$ kJ
4. $O_{(g)} + e^- \rightarrow O^-_{(g)}$	-142 kJ
5. $O^-_{(g)} + e^- \rightarrow O^{2-}_{(g)}$	$+844$ kJ
6. $2Na^+_{(g)} + O^{-2} \rightarrow Na_2O_{(s)}$	-2573.5 kJ
Overall reaction: $2Na_{(s)} + \tfrac{1}{2}O_{2(g)} \rightarrow Na_2O_{(s)}$	-416 kJ

$-416 = 218 + 990 + 247.5 - 142 + 844 + X$

$-416 = 2157.5 + X$

$X = -2573.5$ kJ → L.E.