ChemQuest 29

More Lewis Structures

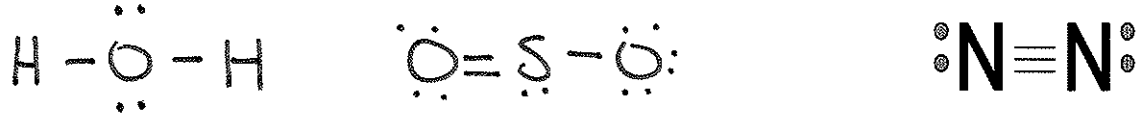
Name: _____

Date: _____

Hour: _____

Introduction Questions

1. Draw the Lewis structures for the following molecules. Part c is done for you.
   a) H_2O (oxygen is central) b) SO_2 c) N_2



2. In question 1 above you should see three different kinds of bonds. Define each of these kinds of bonds as best you can.
   a) single bond:
   one pair (2e⁻) shared

   b) double bond:
   two pairs (4e⁻) shared

   c) triple bond:
   three pairs (6e⁻) shared

3. In general, which kind of bond do you think would be harder to break—a single, double or triple bond? Why?
   triple bond - tighter connection because they are sharing more e⁻

Information: Bond Order, Bond Length and Bond Energy

Study the following table relating bond order, bond length, and bond energy. Note that **bond length** is the distance between two bonding atoms in picometers and **bond energy** is the amount of energy (in kilojoules) required to break one mole of bonds.

Carbon—Carbon Bonds (note: these are drawings of bonds, not entire molecules)	**Bond Order for C—C bonds**	**C—C Bond Length (pm)**	C—C Bond Energy (kJ/mole)
C—C	1	150	350
C=C	2	130	600
C≡C	3	120	830

Critical Thinking Questions

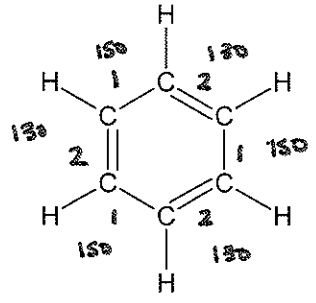
4. Is your answer to question 3 consistent with the data in the table?
   yes, it has the highest bond energy

5. What is the relationship between bond order and single, double, and triple bonds?
   it is the same

6. What relationship exists between bond length and bond energy?
   Shorter the bond, the higher the energy

7. Which bonds are shortest—single, double or triple?
   sir triple

8. A structure for benzene is given below.



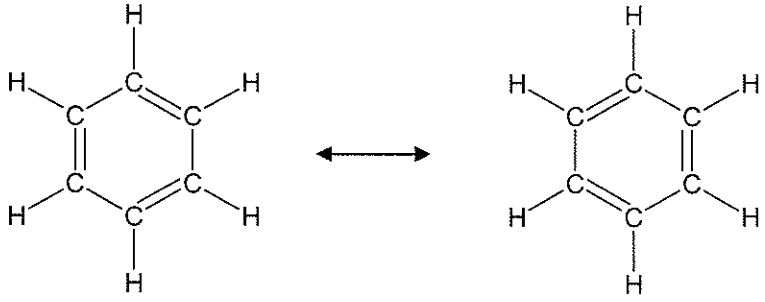
   a) Based on the Lewis structure, what is the bond order for each C—C bond? Label your predictions on the structure above.

   b) What would be the approximate lengths of the carbon-carbon bonds? Label these predictions on the structure also.

Information: Resonance Structures

Experimentally, all of the carbon-carbon bonds in benzene are exactly the same length. All of the bonds also require the same energy to break. This would indicate that all of the carbon-carbon bonds are identical. The bond order of each of the C—C bonds is approximately 1.5. The bonds have characteristics in between those of first order and second order bonds. Therefore, the structure of benzene is best represented by what is called a **resonance structure**. The structure is given at the top of the next page.

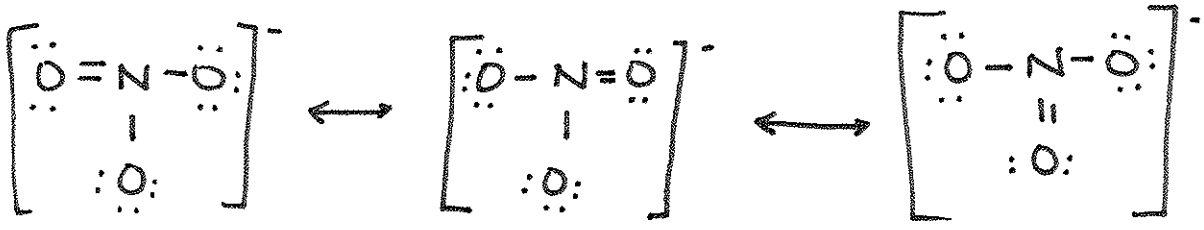
The resonance hybrid representation of benzene:



Note: the only difference in the resonance structures is the position of the double bonds.

Critical Thinking Questions

9. a) The nitrate ion, NO_3^-, is best represented by three resonance structures. Draw the three structures below. Note: the only difference between the three structures you draw will be the position of the double bond.



b) Why were three structures required instead of two?

Three different places the double bond can be.

c) Describe in general terms what you think nitrate's nitrogen-oxygen bonds are like in terms of bond order, bond length, and bond energies.

Bond order is ~1.33
They are shorter than single bonds, but longer than double.
Bond energy is higher than single, lower than double