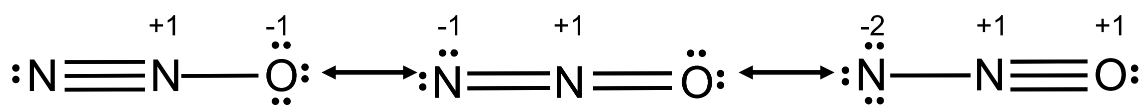
CHEM 121
Spring 2006
Quiz 6

Name: ____

1a. (10 Points) Nitrous oxide (N_2O) has three possible resonance structures. Draw them.

2 N	**2 x 5 = 10**
O	**6**
Total	**16**



Central N: FC = 5 – 0 – ½(8) = +1
Left N, triple bonded structure: FC = 5 – 2 – ½(6) = 0
Left N, double bonded structure: FC = 5 – 4 – ½(4) = -1
Left N, single bonded structure: FC = 5 -6 – ½(2) = -2
Oxygen, single bond: FC = 6 – 6 – ½(2) = -1
Oxygen, double bond: FC = 6 – 4 – ½(4) = 0
Oxygen, triple bond: FC = 6 – 2 – ½(6) = +1

b. (4 Points) Given the following bond lengths (1 Å = 10^{-10} m), rationalize the observations that the N–N bond length in N_2O is 1.12 Å and that the N–O bond length is 1.19 Å.

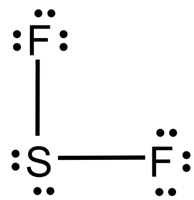
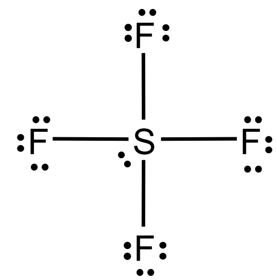
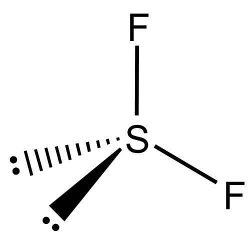
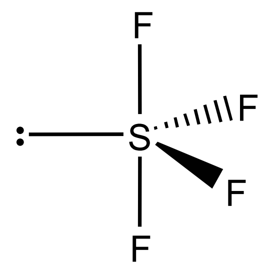
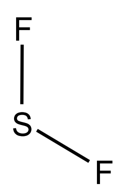
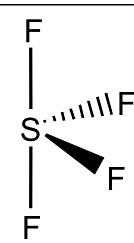
N–N	1.67 Å	N=O	1.15 Å
N=N	1.20 Å	N–O	1.47 Å
N≡N	1.10 Å		

The Electroneutrality Principle (based on minimizing formal charge and the placement of formal charges) predicts that the structure with a N-N triple bond and an N–O single bond should be the most favorable structure and. However, the data indicate that the bond character in the N–N bond is between that of a typical double and a typical triple N–N bond and that the N–O bond is between that that of a typical double and typical single N–O bond. This suggests that the bonding in N_2O is better described by a resonance structure that includes both of the structures shown on the left above. In other words, both the first and second resonance structures shown above contribute to the resonance hybrid description of N_2O.

c. (2 Points) What is the hybridization of the central N?

The central N in N_2O has a linear electron pair geometry and is sp hybridized.

2a. (14 Points) Fill in the following table.

	SF_2	SF_4
Valence electrons	**S 6** **2 F 2 x 7 = 14** **Total 20**	**S 6** **4 F 4 x 7 = 28** **Total 34**
Lewis dot structure		
Electron pair geometry		
Name of the electron pair geometry	**tetrahedral**	**trigonal bipyramidal**
Structure		
Name of structure	**bent**	**see-saw**
Hybridization of S	**sp^3**	**sp^3d**

c. (4 Points) Are either of these molecules polar? Explain.

Both molecules are polar because there is a difference in electronegativity between the S and the F atoms, which results in polar bonds, and the structures are asymmetric, which results in an asymmetric distribution of electrons within the molecule.

3. (10 Points) Ethylenediaminetetraacetic acid (EDTA or H_4EDTA) is used as a complexing agent in chemical analysis. Solutions of EDTA, usually containing the disodium salt, Na_2H_2EDTA, are used to treat heavy metal poisoning.

The reaction of H_2EDTA^{2-} with Cr^{3+} in aqueous solution (shown below) has an equilibrium constant of 1.0×10^{23}.

$$Cr^{3+}(aq) + H_2EDTA^{2-}(aq) \leftrightharpoons CrEDTA^{-}(aq) + 2\,H^{+}(aq)$$

Calculate the $[Cr^{3+}]$ at equilibrium in a solution originally 0.0010 M in Cr^{3+} and 0.050 M in H_2EDTA^{2-} and buffered at pH 6.0.

The $[H^+] = 10^{-pH} = 10^{-6.0} = 1.0 \times 10^{-6}$ M. This will not change because the system is buffered.

The equilibrium constant for this reaction is very large. Therefore, the equilibrium lies almost entirely to the right (there will be very little Cr^{3+} left in solution). To solve the problem we will assume that the reaction goes completely to the right and work the problem from the products side.

	Cr^{3+} (aq)	+ H_2EDTA^{2-} (aq)	⇋ $CrEDTA^{-}$ (aq)	+ 2 H^{+} (aq)
Initial	**0.0010**	**0.050**	**0**	**1.0×10^{-6}**
Initial’	**0**	**0.049**	**0.0010**	**1.0×10^{-6}**
Change	**+x**	**+x**	**-x**	**-------**
Final	**x**	**0.049 + x**	**0.0010-x**	**1.0×10^{-6}**

$$K = \frac{[CrEDTA^{-}][H^{+}]^2}{[Cr^{3+}][H_2EDTA^{2-}]} = \frac{(0.0010 - x)(1.0x10^{-6})^2}{(x)(0.049 + x)} = 1.0x10^{23}$$

Assume that x is negligible with respect to either 0.0010 or 0.049. *This gives*

$$\frac{(0.0010)(1.0x10^{-6})^2}{(x)(0.049)} = 1.0x10^{23}$$

$$x = \frac{(0.0010)(1.0x10^{-6})^2}{(1.0x10^{23})(0.049)} = 2.0x10^{-37}$$

Check by inspection that $2.0x10^{-37}$ is negligible with respect to either 0.0010 or 0.049.

The $[Cr^{3+}]$ at equilibrium is $2.0x10^{-37}$ M.