Assignment Sheet #3 APQ answers

PART I

19

d.) SeF_4 has a distorted tetrahedron shape and is polar due to the presence of the lone pair on the central atom (Se).

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a i.) CO_2 is a linear molecule with carbon as the central atom. Each oxygen atom has a double bond to the carbon atom and each oxygen atom has two lone pairs.
CO_3^{-2} is a classic resonance species. The three resonance forms can be thought of having a "resonating double bond". One resonance form has the carbon atom as the central atom. One oxygen atom is double-bonded to the carbon and has two lone pairs. The other two oxygen atoms are single-bonded to the carbon atom and each has three lone pairs. The three resonance structures differ in which oxygen atom is doubly bound to the carbon atom.

a ii.) CO_2 has two double bonds that are each shorter than the resonance bonds (somewhere between a single bond and a double bond in length) found in the carbonate ion, CO_3^{-2} .

b i.) CF_4 is a tetrahedral shaped molecule, and the central carbon atom has no lone pairs on it. Each fluorine atom is single-bonded to the carbon atom and each has three lone pairs.
SF_4 is a distorted tetrahedral shaped molecule, and the central sulfur atom has one lone pair. Each fluorine atom is single-bonded to the sulfur atom and each has three lone pairs.

b ii.) Carbon tetrafluoride has no lone pairs on the central atom and the dipole moments of each of the C-F bonds cancel one another out whereas sulfur tetrafluoride does have a lone pair on the central atom (S) which creates a molecular dipole moment.

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a.) PF_3 has trigonal pyramidal geometry whereas PF_5 has trigonal bipyramidal geometry.

b.) PF_3 is polar due to the lone pair on the central atom (P).

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b.) AsF_3, which has a trigonal pyramidal shape, has a lone pair on the central atom (As). The lone pair makes it polar. AsF_5 has no lone pairs on the central atom (As) and the bond dipole moments cancel one another within the trigonal bipyramidal molecule. (Hint: supplement your answer with pictures including molecular dipole moment arrows).

c.) The NO_2^{-1} ion exhibits resonance, giving bonds of equal length, but in HNO_2, the bonding of the H atom fixes one oxygen atom's bond to N as a single bond. The other oxygen atom is bonded to the nitrogen with a double bond. There is no resonance in HNO_2.

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b. SO_2 has a dipole moment due to its polar nature, caused by the lone pair on the central atom (S) in each resonance structure. CO_2 has no dipole moment due to its linear shape and the lack of a lone pair on the central atom.

PART II

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c i.) NF_5 cannot exist because the central atom, N, does not have d orbitals with which to form sp^3d hybrid orbitals. Its valence electrons are in n=2, and no d orbitals exist at n=2.

c ii.) AsF_5 can exist because its valence electrons do have d orbitals with which to undergo sp^3d hybridization.

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d.) The central atom sulfur can form hybrid orbitals capable of forming equal bonds with fluorine in SF_4 and SF_6, which oxygen cannot because oxygen electrons on n=2 have no d orbitals available with which to hybridize. Recall that d orbitals start at n=3.

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a.) Liquid oxygen is paramagnetic (has unpaired electrons) according to molecular orbital theory and is thus affected by the magnetic field whereas liquid nitrogen is not paramagnetic - it is diamagnetic – and, as such, is not affected by the magnetic field.

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b. The charge density of the calcium cation is greater than the charge density of the potassium ion; the calcium ion has a +2 charge, whereas the potassium ion has a +1 charge. In each case, the oxygen ion's charge/volume ratio is identical.

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In Na_3As, an ionic compound, the arsenic atom has formed a –3 ion, which attracts 3 Na^{+1} ions.
In $AsCl_3$, a molecule, the arsenic atom shares its 3 unpaired 4p electrons with the 3 chlorine atoms, forming single covalent bonds with each of the chlorine atoms.
In AsF_5, the arsenic atom forms sp^3d hybrid orbitals, each of which can make a single covalent bond with one fluorine atom.