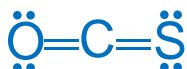


Complete the following problems. You must show your work to receive full credit. Show your answers to the correct number of significant figures with the correct units.

1. There are three possible Lewis structures for the compound OCS. Draw the three structures below and identify which structure, if any, you would expect to most closely describe the real structure of OCS. Justify your answer. (8 pts)



FC: 0 0 0



FC: +1 0 -1



FC: -1 0 +1

Since the structure on the left has formal charge of zero on all atoms, it would be the preferred structure.

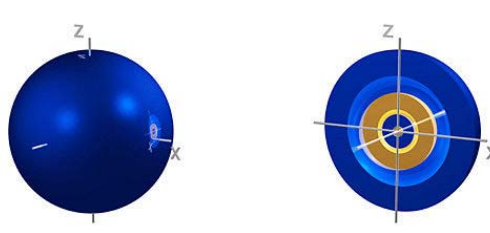
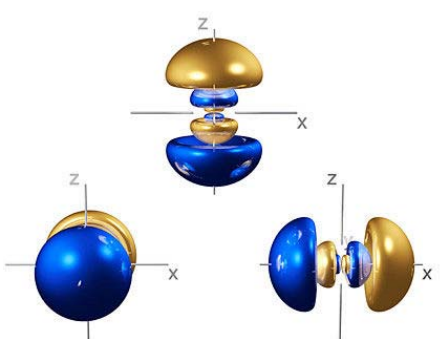
2. Concisely explain the following observations: (8 pts)  
a. Sodium has an atomic radius of 186 pm, while chlorine atoms and sodium ions both have radii of 99 pm.

**Sodium cation is smaller than sodium atom because the effective nuclear charge increases when losing an electron. Also, in  $\text{Na}^+$  the largest orbital occupied is of a smaller principle quantum number.**

**Sodium cations and chlorine atoms have the same electron configuration, with the 3p orbital completely full. Effective nuclear charge has only minimal effect on size across the p orbital, so it is reasonable that  $\text{Na}^+$  and  $\text{Cl}^0$  have similar size.**

- b. The first ionization energy of magnesium is much larger than the first ionization energy of aluminum, which is larger than the ionization energy of sodium.  
**Ionization of Mg requires removal of an electron from a filled 3s orbital, which requires significant energy due to the stability of filled orbitals. Ionization of Al requires the loss of an electron from a partially filled orbital and results in a filled orbital, while ionization of Na results in a filled valence shell, requiring the least energy of the three.**

3. Complete the table below. (8 pts)

Orbital	4s orbital	4p orbital
Sketch	 <p style="text-align: center;">SCIENCEPHOTOLIBRARY</p>	 <p style="text-align: center;">SCIENCEPHOTOLIBRARY</p>
Number of Radial Nodes	<b>3</b>	<b>2</b>
Number of Angular Nodes	<b>0</b>	<b>1</b>

**Bonus (4 pts):** Complete the following table (spelling counts!)

Formula	Name
$\text{Fe}_3(\text{HPO}_4)_3$ (should be $\text{FeHPO}_4$ )	iron (II) hydrogen phosphate
$\text{Mg}(\text{NO}_3)_2$	magnesium nitrate

### Possibly Useful Information

1 1A	2 2A																	18 8A	
1 H 1.00794																			2 He 4.00260
3 Li 6.941	4 Be 9.01218																		
11 Na 22.9898	12 Mg 24.3050	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 9B	10 10B	11 11B	12 12B	13 Al 26.9815	14 Si 28.0855	15 P 30.9738	16 S 32.066	17 Cl 35.4527	18 Ar 39.948		
19 K 39.0983	20 Ca 40.078	21 Sc 44.9559	22 Ti 47.88	23 V 50.9415	24 Cr 51.9961	25 Mn 54.9381	26 Fe 55.847	27 Co 58.9332	28 Ni 58.693	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80		
37 Rb 85.4678	38 Sr 87.62	39 Y 88.9059	40 Zr 91.224	41 Nb 92.9064	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.906	46 Pd 106.42	47 Ag 107.868	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.757	52 Te 127.60	53 I 126.904	54 Xe 131.29		
55 Cs 132.905	56 Ba 137.327	57 *La 138.906	72 Hf 178.49	73 Ta 180.948	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.967	80 Hg 200.59	81 Tl 204.383	82 Pb 207.2	83 Bi 208.980	84 Po (209)	85 At (210)	86 Rn (222)		
87 Fr (223)	88 Ra 226.025	89 †Ac 227.028	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (271)	111 Rg (272)									

*Lanthanide series	58 Ce 140.115	59 Pr 140.908	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.965	64 Gd 157.25	65 Tb 158.925	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.967
†Actinide series	90 Th 232.038	91 Pa 231.036	92 U 238.029	93 Np 237.048	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)