Updated April 23/07 **CHAPTER 9 ANSWERS**

NUMERICAL ANSWERS TO ASSIGNED TUTORIAL PROBLEM SETS FOR CHEM205
FROM KOTZ & TREICHEL'S CHEMISTRY & CHEMICAL REACTIVITY, **6th Ed.**

NOTE: only <u>some</u> of the answers from Ch.9 have been verified. Please report any errors.

Ch.	Q#	Comments
9	2	C: Group 14 (4A) 4 valence electrons (e^-) Cl: Group 17 (7A) 7 valence e^- Ne: Group 18 (8A) 8 valence e^- Si: Group 14 (4A) 4 valence e^- Se: Group 16 (6A) 6 valence e^- Al: Group 13 (3A) 3 valence e^-
9	4	P, Cl, Se, and Sn can accommodate more than 4 valence e^-'s
9	6	MgCl (Mg typically forms Mg^{2+} ions) BaF_3 (Ba typically forms Ba^{2+} ions) CsKr (Kr is unlikely to form a Kr^- ion)
9	10a	NaCl (shorter distance)
	10b	MgO (shorter distance)
	10c	MgS (higher charge)
9	12	CS_2 is like CO_2, see page 333, NO_2^- see page 363, BF_4^- see Table 9.6, p339 Cl_2SO is pyramidal, S central, with Cl-S single bonds, and an S=O double bond, or alternatively, with all single bonds. Both have one lone pair on S.
9	16	It is possible to draw 3 for each which obey the octet rule, but some are more reasonable than others.

VSEPR shorthand: A = central atom; B = bonded peripheral atom; E = lone pair; subscripts denote # of B or E

9	18a	BrF_5: "electron pair geometry": octahedral (AB_5E); molecular geometry: square pyramidal.
	18b	IF_3: "electron pair geometry": trigonal bipyramidal (AB_3E_2); molecular geometry: T-shaped.
	18c	IBr_2^-: "electron pair geometry": trigonal bipyramidal (AB_2E_3); molecular geometry: linear.
	18d	BrF_2^+: "electron pair geometry": tetrahedral (AB_2E_2); molecular geometry: bent.
9	20a	ClF_2^+: "electron pair geometry": tetrahedral (AB_2E_2); molecular geometry: bent
	20b	$SnCl_3^-$: "electron pair geometry": tetrahedral (AB_3E); molecular geometry: trigonal pyramidal
	20c	PO_4^{3-}: "electron pair geometry": tetrahedral I(AB_4); molecular geometry: tetrahedral
	20d	CS_2: "electron pair geometry: linear (AB_2); molecular geometry: linear
9	22a	CO_3^{2-}: "electron pair geometry": trigonal (AB_3); molecular geometry: trigonal
	22b	NO_3^-: "electron pair geometry": trigonal (AB_3); molecular geometry: trigonal
	22c	SO_3^{2-}: "electron pair geometry": tetrahedral (AB_3E); molecular geometry: trigonal pyramidal
	22d	ClO_3^-: "electron pair geometry: tetrahedral (AB_3E); molecular geometry: trigonal pyramidal

Ch.	Q#	Comments
9	24a	SiF_6^{2-}: "electron pair geometry": octahedral (AB_6); molecular geometry: octahedral
	24b	PF_5: "electron pair geometry": trigonal bipyramidal (AB_5); molecular geometry: trigonal bipyramidal
	24c	SF_4: "electron pair geometry": trigonal bipyramidal (AB_4E); molecular geometry: "see-saw"
	24d	XeF_4: "electron pair geometry: octahedral (AB_4E_2); molecular geometry: square planar
9	26a	SCl_2: 109°
	26b	NNO: 180°
	26c	CH_2CHOH: angle 1: 120°, angle 2: 120°, angle 3: 109°
9	32a	SO_2 (O-S=O) (pairs not shown) O = -1, S = 0, O = 0
	32b	$SOCl_2$ (see Q39) First structure: all have zero formal charge, or, with all single bonds, Cl's = 0, S = +1, O = -1.
	32c	SO_2Cl_2 if drawn with all bonds single: Cl's = 0, S = +2, O's = -1. Alternative Lewis structures with one or 2 S=O double bonds can be drawn. (See 49b)
	32d	FSO_3^- has S central and if drawn with all bonds single, F = 0, O = -1, S = +2. Again, alternatives with S=O bonds can be drawn, reducing the charge on S by 1 for each.
9	34	(a) N, (b) C, (c) Br, (d) O
9	36a	All are polar.
	36b	The C=O bond is most polar, and the O is the more negative atom.
9	38a	H_3O^+: Even though the formal charge on O is +1, and on H is zero, H is less electronegative. The three H atom therefore are likely to bear the positive charge. The O-H bonds are polar with H the positive end.
	38b	NH_4^+: Even though the formal charge on N is +1, and on H is zero, H is less electronegative. The four H atom therefore are likely to bear the positive charge. The N-H bonds are polar with H the positive end.
	38c	NO_2^+: The formal charge on N is +1 and on O it is zero. This conforms to the relative electronegativities. The bonds are polar, with O the negative end.
	38d	NF_4^+: The formal charge on N is +1 and on F it is zero. This conforms to the relative electronegativities. The bonds are polar, with F the negative end.
9	40a	Yes. Both have 24 valence electrons.
	40b	CO_3^{2-} has three reasonable resonance structures. It is possible to draw a fourth for BO_3^{3-} bearing in mind that B sometimes has only 6 electrons, e.g. BF_3.
	40c	CO_3^{2-}: C = 0, double bonded O's = 0, single bonded O's = -1. BO_3^{3-}: B = -1 for the three structures like CO_3^{2-}, and 0 for the 4th which has all B-O sinfle bonds.
	40d	The H^+ would attach to an oxygen.
9	44a	CH_4: electronegativity difference 2.5 - 2.1 = 0.4
	44b	***FIXED:*** NH_2Cl: electroneg. diff. for N-H: 3.0 – 2.1 = 0.9; for N-Cl: 3.0 - 3.0 = 0
	44c	BF_3: electroneg. diff. 4.0 - 2.0 = 2.0
	44d	CS_2: electroneg. diff. 2.5 - 2.5 = 0
	44i	***FIXED:*** The B-F bonds in BF_3 are most polar (even though the molecule overall is nonpolar).
	44ii	***FIXED:*** All of the molecules except NH_2Cl are nonpolar.
9	48a	CN^-: one C to N triple bond (Bond Order, BO = 3).
	48b	CH_3CN: three C-H single bonds (BO=1), one C-C single bond (BO=1), one C to N triple bond (BO=3).
	48c	SO_3: two S-O single bonds (BO=1), one S=O double bond (BO=2); with resonance, BO=1.33 average.
	48d	$CH_3CH=CH_2$: six C-H single bonds (BO=1), one C-C single bond (BO=1), one C=C double bond (BO=2)

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9	50	(a) Si-O, (b) C-O, (c) C-F, (d) C to N triple bond.
9	52	HCO_2^-: one CO single bond, one CO double bond, two resonance structures; avg. CO bond order = 3/2
9	52	CH_3OH: one CO single bond; CO bond order = 1
9	52	CO_3^{2-}: two CO single bonds, one CO double bond, three resonance structures: avg CO bond order = 4/3
9	52	CH_3OH has the longest CO bond (lowest bond order); HCO_2^- has the shortest CO bonds (highest BO)
9	54	H_2N_2: N-N single bond, BO=1. N_2O has bond order greater than one, so has shorter, stronger N-N bond.
9	64	BCl_3: trigonal planar, sp^2 hybridized boron. BH_3-NH_3 has sp^3 hyb. boron due to extra bond to ammonia N.
9	72	Electroneutrality principle: electrons are distributed in a molecule in such a way that the charges on the atoms are as close to zero as possible, and add up to the total charge on the molecule. When a – charge occurs, e^-s should be placed such that the negative formal charge ends up on the most electronegative atom, if possible; conversely, any + formal charges should be on the least electronegative atom possible.
9	76	NO_2^- (trigonal-planar electron-pair geometry) has a smaller bond angle (~120°) than NO_2^+ (linear geometry, ~180° bond angle).
9	84a	Angle 1 = 120°, angle 2 = 109°, angle 3 = 120°.
	84b	The C=O bond is the shortest C to O bond in the molecule.
	84c	The O-H bond is the most polar: electronegativity difference = 3.5 - 2.1 = 1.4.
9	90a	S: 6-(4+(1/2)2) = 0; O: 6-(4+(1/2)4) = 0
9	90b	angle 1 = 109.5°; angle 2 = 109.5°; angle 3 = 120°.
9	90c	The C=C bonds are shorter than the C-C bonds.
9	90d	The C-O bond is most polar.
9	90e	The molecule is polar.
9	90f	The 4 C atoms are trigonal planar & lie in the same plane (are coplanar), so the ring as a whole is planar.
9	96a	BF_3: 26 valence e^-s; B central; trigonal planar e^-pair geometry; trigonal planar molecular geometry
9	96b	CF_4; 32 valence e^-s; C central; tetrahedral planar e^-pair geometry; tetrahedral molecular geometry
9	96c	PF_3: 20 valence e^-s; P central; tetrahedral planar e^-pair geometry; trigonal pyramidal molec. geometry
9	96d	OF_2: 16 valence e^-s; O central; tetrahedral planar e^-pair geometry; bent molecular geometry
9	96e	HF: 8 valence e^-s; linear; linear planar e^-pair geometry molecular geometry
9	98	Bond dissociation energy is the enthalpy change (energy required) for breaking a bond in a molecule with the reactants and products in the gas phase. The process of breaking bonds is ALWAYS endothermic (requires heat input); the value always has a positive sign.
9	100	In water, there are four electron pairs around the O atom. The electron-pair geometry is the geometry adopted by these four pairs. The molecular geometry is the geometry described by the atoms of the molecule. In water, the electron-pair geometry is tetrahedral, whereas the molecular geometry is bent.
9	102a	The two resonance structures differ only on the side of the molecule with the C(O)-NH_2. In the most stable structure, there is a C=O bond and a C-N bond; in the other structure, there is a C-O bond and a C=N bond, with a negative formal charge on oxygen and a positive formal charge on nitrogen.
9	102b	The bond angles around N are approximately 109°. All other angles are 120°.
9	102c	The C=C bond is stronger than the C-C bond.
9	102d	The molecule is polar.
9	102e	28g of chips contains 6.7×10^{-7} mol of acrylamide (MM=71.1g/mol, but only 1.7mg/1000g chips).