

USE PEN ONLY

ANSWER KEY (PRINT)
LAST NAME, FIRST NAME

SECTION

1. _____ (25pts)

2. _____ (25pts)

3. _____ (25pts)

4. _____ (25pts)

_____(Total)

SHOW ALL WORK!

All essay questions must be answered with complete sentences. All calculations must be clearly shown with units and their cancellations in at least one step of the problem. Answers must have the proper number of significant figures. Only exams written in ink are eligible for a re-grade. Academic Integrity is expected of everyone and anyone caught cheating will receive an F in the course.

1. _____ (25pts)

_____ **Print Initials**

(5pts for each question, all or nothing, place the letter answer on the line provided before the question)

___ **D** ___ (i) Select the diamagnetic ion:

- (A) Cu^{2+} (B) Ni^{2+} (C) Cr^{3+} (D) Sc^{3+} (E) Cr^{2+}

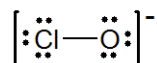
___ **A** ___ (ii) Which of the following is the most acidic compound?

- (A) SO_2 (B) Al_2O_3 (C) CaO (D) PbO (E) H_2O

___ **B** ___ (iii) Which of the following molecules has a net dipole moment?

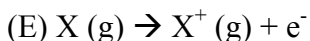
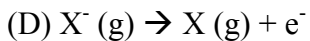
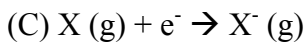
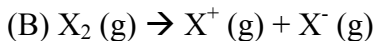
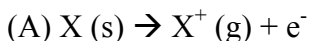
- (A) BeCl_2 (B) SF_2 (C) KrF_2 (D) CO_2 (E) CCl_4

___ **B** ___ (iv) The formal charges on Cl and O in the structure shown for the ClO^- ion are, respectively



- (A) -1, 0 (B) 0, -1 (C) +1, -2 (D) -2, +1 (E) -1, -2

___ **E** ___ (v) Which of the following equations correctly represents the process relating to the ionization energy of X?



2. _____ (25pts)

_____ **Print Initials**

(5pts for each question, all or nothing, place the letter answer on the line provided before the question)

___ **A** ___ (i) Which contains both covalent and ionic bonds?

- (A) NH_4NO_3 (B) NF_3 (C) BaCl_2 (D) CH_2O (E) BeCl_2

___ **D** ___ (ii) According to modern bonding theory the total number of sigma (σ) and pi (π) bonds in $\text{H}_2\text{C}=\text{CHCH}_3$ is

- (A) 1 σ and 4 π
(B) 1 σ and 1 π
(C) 1 π and 4 σ
(D) 1 π and 8 σ
(E) 2 π and 5 σ

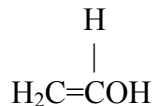
___ **B** ___ (iii) What is the electron configuration of Mn^{2+} ?

- (A) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^7$
(B) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$
(C) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$
(D) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^5$
(E) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^4$

___ **E** ___ (iv) Which of these isoelectronic ions is the smallest?

- (A) O^{2-} (B) F^- (C) Na^+ (D) Mg^{2+} (E) Al^{3+}

___ **D** ___ (v) What is the approximate C-C-O bond angle in the following molecule?



- (A) 60° (B) 90° (C) 109.5° (D) 120° (E) 180°

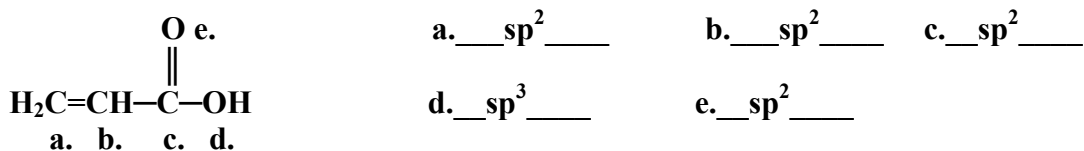
3. _____ (25pts)

Print Initials

(15 points) Identify the shapes of the following molecules by placing the letter of the appropriate shape on the line next to the molecule. (Please use capital letters.) Shapes can be used more than once and not all shape names will be used.

- | | |
|--|-------------------------|
| 1. NHCl_2 _____ D _____ | A. Linear |
| 2. BrF_5 _____ H _____ | B. Bent |
| 3. ClF_3 _____ F _____ | C. Trigonal Planar |
| 4. KrBr_2 _____ A _____ | D. Trigonal Pyramidal |
| 5. SO_4^{2-} _____ G _____ | E. See-Saw |
| 6. IF_2^- _____ A _____ | F. T-Shaped |
| | G. Tetrahedral |
| | H. Square Pyramidal |
| | I. Square Planar |
| | J. Octahedral |
| | K. Trigonal Bipyramidal |

(5 points) State the hybridization of the labeled atoms in the following molecule:



(5 points) Draw a reasonable Lewis Structure for POCl_3 (show all lone pair electrons)

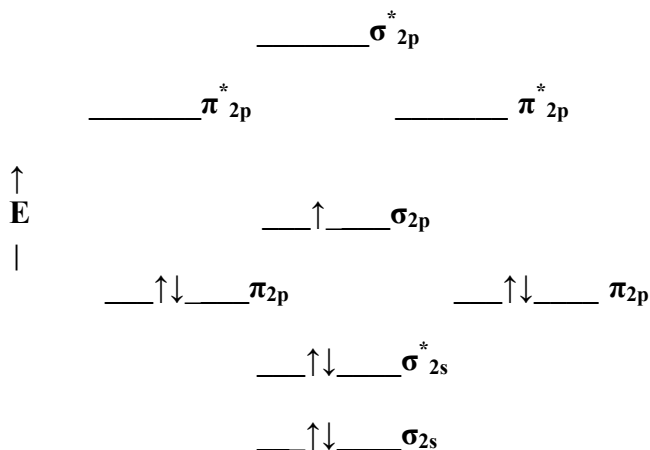
The first structure (A) will have two lone pairs of electrons on the oxygen and three lone pairs of electrons on each chlorine. The second acceptable structure (B) will have three lone pairs on each chlorine and three lone pairs on the oxygen.



4. _____ (25pts)

_____ **Print Initials**

(9 points) Fill in the diagram for the ground state configuration showing all “valence electrons” and their spins for the CO^+ ion. Use the energy diagram below.



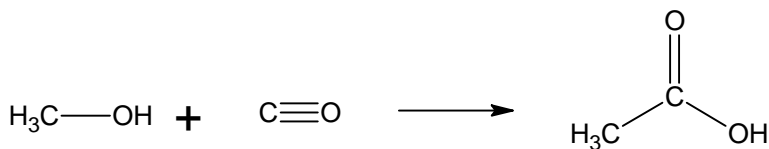
b. 2.5 (4pts) What is the bond order in CO^+ ? (Show Calculation)

$$\frac{1}{2} (\# \text{ of electrons in bonding MOs} - \# \text{ of electrons in antibonding MOs}) = \text{BO}$$

$$\frac{1}{2} (7-2) = 2.5$$

c. paramagnetic (3pts) Is the molecule paramagnetic or diamagnetic?

(9 points) Calculate the heat of reaction ($\Delta H^\circ_{\text{rxn}}$, in kJ) for the formation of acetic acid from methanol and carbon monoxide:



Bond Energies (kJ/mol): C-H 413, C-O 358, C-C 347, O-H 467, C=O 745, $\text{C}\equiv\text{O}$ 1070

$$\Delta H^\circ_{\text{rxn}} = [(3 \cdot 413) + (358) + (467) + (1070)] - [(3 \cdot 413) + (347) + (745) + (358) + (467)]$$

$$\Delta H^\circ_{\text{rxn}} = -22 \text{ kJ}$$