EXAM INSTRUCTIONS/SUGGESTIONS.
READ THIS CAREFULLY!

YOU MAY OMIT ANY THREE (3) OF THE FIFTEEN 6 POINT QUESTIONS ON THIS EXAM. IF YOU DO MORE THAN TWELVE OF THEM, ONLY THE FIRST TWELVE WILL BE GRADED. ALL OTHER QUESTIONS MUST BE ANSWERED.

INDICATE ON THE NEXT PAGE WHICH THREE QUESTIONS ARE NOT TO BE GRADED BY WRITING DNG (DO NOT GRADE) NEXT TO PROBLEM NUMBER.

NO PARTIAL CREDIT on any question except where indicated by the statement SHOW WORK. When work is requested, set up equations (with numbers substituted in appropriate units) in space provided, but do the calculations on scrap sheet.

IF THE QUESTION STATES "SHOW WORK" AND YOU GUESS CORRECTLY WITHOUT SHOWING WORK - YOU GET 1/2 CREDIT.

CHECK FRONT BLACKBOARD FOR CORRECTIONS/CHANGES.

DO THE SIMPLER QUESTIONS FIRST.

IF ANY QUESTION IS NOT CLEAR - ASK TANUJA OR ME ABOUT IT!

CONSTANTS AND CONVERSION FACTORS ARE ON THE PAGE AT THE END OF THE EXAM. PLEASE LOOK THERE!
LAST THREE PAGES ARE FOR SCRAP WORK.
FEEL FREE TO TEAR THESE PAGES OFF.

FIRST REMINDER: FINAL EXAM ON WEDNESDAY, AUGUST 11th FROM 9 AM TO 12 NOON.

PLEASE REMOVE THIS SHEET PRIOR TO STARTING EXAM.

CHEMISTRY S14O4 SECOND EXAM 7/29/99
PROFESSOR J. MORROW

PRINT NAME, LAST: _____

FIRST: _____

I.D.# : _____

MAXIMUM POINT VALUE IS IN PARENTHESIS

1. _____(6)	9. _____(10)	17. _____(6)
2. _____(9)	10. _____(20)	18. _____(6)
3. _____(10)	11. _____(6)	19. _____(6)
4. _____(20)	12. _____(6)	20. _____(6)
5. _____(6)	13. _____(6)	21. _____(6)
6. _____(15)	14. _____(10)	22. _____(6)
7. _____(12)	15. _____(6)	23. _____(6)
8. _____(8)	16. _____(6)	24. _____(6)

COLUMN TOTALS: (MAXIMUM)

_____(86) _____(70) _____(48)

EXAM TOTAL (186 pts) _____ _____
OUT OF 1OO

1)

Ionization Energies (kJ/mol)

	Fe	
First		759
Second	1561	
Third		2957
Fourth	____	4175

A compound, ilmenite, ($FeTiO_3$) is composed of either Fe^{2+} and Ti^{4+} ions OR Fe^{3+} and Ti^{3+} ions. Which combination, (Fe^{2+} and Ti^{4+}) or
(Fe^{3+} and Ti^{3+}) is more reasonable. (6 pts) SHOW WORK

ANSWER IS: _____

2) Give the electronic configuration ($1s^2$ etc) and the number of unpaired electrons (UE) in each of the following gaseous atoms/ions. (9 pts - 3 pts each: 2 pts/1 pt)

Cu UE =

Cu^+ UE =

Cu^{2+} UE =

3) An ionic crystalline solid, MX_3 , has a cubic unit cell. Which of the following arrangements of the ions is consistent with the stoichiometry of the compound? (10 pts)

i) M^{3+} ions at the corners, X^- ions at the face centers.

ii) M^{3+} ions at the corners, X^- ions at the body center.

iii) X^- ions at the corners, M^{3+} ions at the face centers.

iv) X^- ions at the corners, M^{3+} ions at the body center.

v) M^{3+} ions at the corners and the body center, X^- ions at the face centers.

ANSWER IS: _____

4) Magnetite, Fe_3O_4 (231.54 $\frac{g}{mol}$), has a density of 4.897 $\frac{g}{cm^3}$. It is an orthorhombic crystal with a = b = 11.86 Å and c = 16.75 Å.
How many formula weight units of Fe_3O_4 are there per unit cell? How many Fe^{2+} ions and how many Fe^{3+} ions are there <u>per unit cell</u>?
(20 pts) SHOW WORK

The number of formula weight units is:

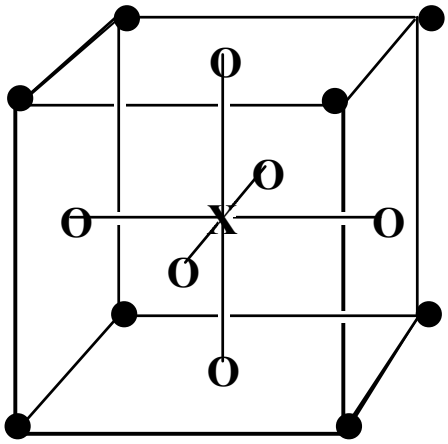
i) 12 ii) 15 iii) 24 iv) 30 v) 36

# of Formula weights: _____

of Fe^{2+} ions: _____

of Fe^{3+} ions: _____

5) Pervoskite is a material containing calcium, titanium, and oxygen.
The cubic unit cell is shown below.



X = Ti^{4+}

O = O^{2-}

● = Ca^{2+}

Ionic radii: Ti^{4+} 0.360 Å; O^{2-} 1.450 Å

density = 4.759 g/cm^3 Molar mass = 135.96 g/

Calculate the unit cell edge length in Å. (6 pts)

ANSWER IS: _____

6) Osmium is one of the worlds most expensive elements. The abundance of osmium is $2x10^{-4}$ ppm (parts per million) and it has a melting point of

3045°C. Last year one kilogram of this element sold for 78 *million* dollars. Aside from all of this fascinating information, osmium crystallizes in a face centered cubic lattice. The atomic radius of osmium is 1.352 Å, and its molar mass is 190.2 $\frac{g}{mol}$.

a) Calculate the density of osmium. (10 pts) SHOW WORK

ANSWER IS: _____

b) Calculate its molar volume ($\frac{cm^3}{mol}$). (5 pts)

ANSWER IS: _____

7) Give the hybridization for each underlined atom in the following ions. Also give the actual spatial appearance of the ion. If the ion cannot exist, write CNE, in space provided. (ie. sp^2 / trigonal)
Group numbers: N (5) , Cl (7) , S (6) , F (7) (12 pts - 3 pts each)

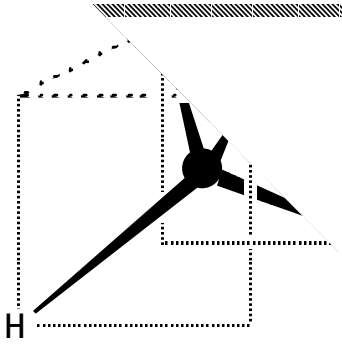
i) $\underline{I}F_4^+$ _____/_____

ii) $\underline{S}F_5^+$ _____/_____

iii) $\underline{N}F_4^-$ _____/_____

iv) $\underline{B}F_4^+$ _____/_____

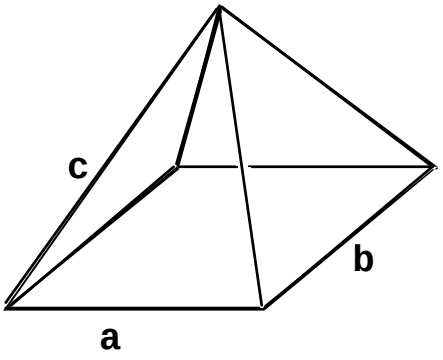
8) State how many of each of the following types of elements of symmetry exist in chlorofluoromethane. (8 pts)



chlorofluoromethane

SP^3 hybridized

9) State how many of each of the following types of elements of symmetry exist in square based pyramid below. (10 pts)



a = b = c

center of symmetr

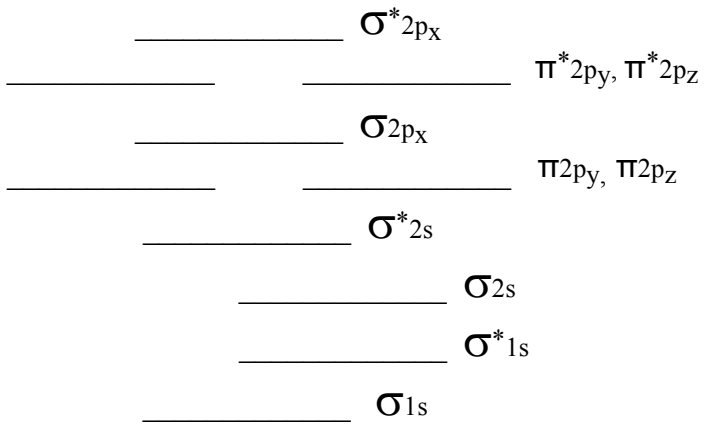
two fold axis of rotation, C_2

three fold axis of rotation, C_3

four fold axis of rotation, C_4

planes of symmetry

Use the MO correlation diagram below (where needed) to answer questions 10, 11, and 12.



10) Predict the apparent bond order, relative bond length, and number of unpaired electrons in the following species; CO , BN, and BeC . Where relative values are compared, use < or > otherwise use the calculated numerical values. (20 pts)

	CO	BN	BeC
Bond order			
Bond Length			
Bond enthalpy			
Number of unpaired electrons			

11) If light of the proper wavelength is used an electron in the π_{2p_y} molecular orbital is excited to the $\pi^*_{2p_y}$. What is the bond order after this transition in BeC? (6 pts)

bond order =

12) List the following in order of increasing bond length: Li_2, Ne_2^+, and F_2 . (6pts)

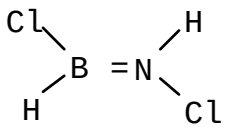
_____ < _____ < _____

13) The bond order of each of the following, C-H , O-H , and F-H, is 1. List them in order of decreasing bond enthalpy. (6 pts)

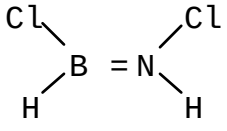
_____ > _____ > _____

14) The molecule BNH_2Cl_2 exists in two forms, a cis form and a trans form.

GIVEN: Bond enthalpies (kJ/mol): B=N (511); N-N (163); B-N (212); N-H (388); N-Cl (381); B-H (551); Cl-Cl (243); B-Cl (349)



trans



cis

Calculate the energy per molecule, ($\frac{J}{molecule}$), required to convert the trans form to the cis form. (10 pts)

i) 8.48×10^{-19} ii) 4.97×10^{-19} iii) 3.52×10^{-19} iv) 2.67×10^{-19}

ANSWER IS: _____

THE FOLLOWING PERIODIC TABLE MAY BE OF USE IN ANSWERING THE REMAINING PROBLEMS.

Group Number

Period	IA	IIA	IIIA	IVA	VA	VIA	VIIA	Inert gas	
2	Li 1.0	Be 1.5	B 2.0	C 2.5	N 3.0	O 3.5	F 4.0		
3	Na 0.97	Mg	Al 1.5	Si	P 2.1	S 2.5	Cl 3.0		
4	K 0.90	Ca	Ga	Ge	As	Se 2.4	Br 2.8		
5	Rb 0.87	Sr	In	Sn	Sb	Te	I 2.5		

Beneath most symbols are electronegativity values. P use them where necessary in answering this question.

15) List the following atoms in order of decreasing 2nd ionization energy: O, S, and K. (6 pts) _____ > _____ > _____

16) List the following in order of decreasing radius.
Na^+, Mg^+, and K^+. (6 pts) _____ > _____ > _____

17) List the ions S^{2-}, P^{3-}, and N^{3-}, in order of increasing ionic radius, that is, the largest is last. (6 pts) _____ < _____ < _____

18) List the following ions in order of decreasing ionic radius.
Li^{+}, Be^{3+}, and B^{+} (6 pts) _____ > _____ > _____

19) List the following gases in order of decreasing molecular bond enthalpy P_2 , S_2 , and Cl_2 . Lowest goes last. (6 pts)
_____ > _____ > _____

2O) List the following atoms in order of decreasing 3rd ionization energy. Li, Na, and Al (6 pts) _____ > _____ > _____

21) Which of these molecules is/are non-polar ; IF_3 , BF_3 , NF_3 , SF_4 , XeF_4?
(6 pts)
ANSWER: _____

22) Circle the stronger acid in each of the following pairs.

i) $H_2S_2O_3$ or $H_2S_4O_6$ (3 pts)

ii) HIO_3 or $HClO_3$ (3 pts)

23) Match up the following bond enthalpies (in kJ/mol), 163, 36O, 412, and 436, , with the indicated molecules; (6 pts)

H-H _____ C-H _____ C-O _____ N-N _____

24) In a multi-electron atom, how many electrons can have the following sets of quantum numbers? (6 pts - 2 pts each)

i) $n = 3$, $m_\lambda = 0$, $m_s = -\frac{1}{2}$ _____

ii) $n = 4$, $m_\lambda = -2$, $m_s = +\frac{1}{2}$ _____

iii) $n = 4$, $m_\lambda = +2$ _____

CONVERSION FACTORS and POTENTIALLY (BUT NOT NECESSARILY) USEFUL EQUATIONS

$C = 3.00 \times 10^{8}$ m/sec $= 3.00 \times 10^{10}$ cm/sec

$h = 6.626 \times 10^{-34}$ J·sec $= 6.626 \times 10^{-27}$ erg·sec

$m_e = 9.108 \times 10^{-28}$ g $= 9.108 \times 10^{-31}$ kg

$\varepsilon = h\nu$

$N_A = 6.022 \times 10^{23}$

$R = 0.0821 \ \frac{L \cdot atm}{mol \cdot degK} = 82.1 \ \frac{cm^3 \cdot atm}{mol \cdot degK}$

$\lambda\nu = c$

1 Å = 0.1 nm $= 10^{-8}$ cm $= 10^{-10}$ m

$\lambda = \frac{h}{p}$ (deBroglie equation) where $p = mv$

Heisenberg Uncertainty principle: $\Delta P \Delta X = \frac{h}{4\pi}$ where $p = mv$

kinetic energy: $\varepsilon = \frac{1}{2} mv^2 = \frac{p^2}{2m}$ where $p = mv$

$q = e = 1.6022 \times 10^{-19}$ coulombs $= 4.806 \times 10^{-10}$ esu

1 eV $= 1.6022 \times 10^{-19}$ J

$\varepsilon_n = - \frac{2.179 \times 10^{-18}}{n^2}$ J

$\varepsilon = qV = h\nu - \Phi$

UNIT RELATIONSHIPS

1 amp = 1 $\frac{coulomb}{sec}$ 1 volt·coulomb = 1 Joule

1 esu^2 = 1 erg·cm 1 Watt = 1 $\frac{joule}{sec}$

1 Joule = 1×10^{7} erg 1 Joule = 1 $\frac{kg \cdot m^2}{sec^2}$ 1 erg = 1 $\frac{g \cdot cm^2}{sec^2}$

SCRAP WORK SHEET

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