DESTROY

ANSWER KEY

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

Fe^{3+} and Ti^{3+} requires 9897 kJ to form
Fe^{2+} and Ti^{4+} requires 11,115 kJ to form

ANSWER IS: Fe^{3+} and Ti^{3+}

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 $1s^2,2s^2,2p^6,3s^2,3p^6,4s^2,3d^9$ UE = 1
OR $1s^2,2s^2,2p^6,3s^2,3p^6,4s^1,3d^{10}$

Cu^+ $1s^2,2s^2,2p^6,3s^2,3p^6,4s^1,3d^9$ UE = 2
OR $1s^2,2s^2,2p^6,3s^2,3p^6,4s^0,3d^{10}$ UE = 0

Cu^{2+} $1s^2,2s^2,2p^6,3s^2,3p^6,4s^0,3d^9$ UE = 1

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: i

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 per unit cell?
(20 pts) SHOW WORK

The number of formula weight units is:
i) 12 ii) 15 iii) 24 iv) 30 v) 36

$$\frac{\text{molecules}}{\text{uc}} = \left(\frac{\text{molecules}}{\text{mol}}\right)\left(\frac{\text{mol}}{\text{g}}\right)\left(\frac{\text{g}}{\text{cm}^3}\right)\left(\frac{\text{cm}^3}{\text{Å}^3}\right)\left(\frac{\text{Å}^3}{\text{uc}}\right)$$

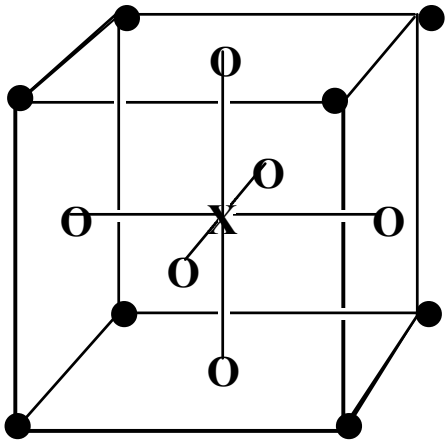
$$\frac{\text{molecules}}{\text{uc}} = (6.022\times10^{23})\left(\frac{1}{231.54}\right)(4.897)(10^{-24})(16.75)(11.86)^2 = 30$$

(12 pts) # of Formula weights: 30

(4 pts) # of Fe^{2+} ions: 30

(4 pts) # of Fe^{3+} ions: 60

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



Ionic radii: Ti^{4+} 0.360 Å; O^{2-} 1.450 Å
density = 4.759 g/cm^3 Molar mass = 135.96 g/mol

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

unit cell edge length = 2(0.360 Å) + 2(1.450 Å)

ANSWER IS: 3.62 Å

6) Osmium is one of the worlds most expensive elements. The abundance of osmium is 2×10^{-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 $\frac{g}{mol}$. (15 pts)

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

FOR fcc unit cell, $a = (8^{1/2})r = (2.829)(1.352) = 3.824$ Å (3 pts)

$$\frac{g}{cm^3} = (\frac{g}{mol})(\frac{mol}{molecule})(\frac{molecules}{uc})(\frac{uc}{Å^3})(\frac{Å^3}{cm^3})$$

$$\text{density} = (19O.2)(\frac{1}{6.O22x1O^{23}})(4)(\frac{1}{3.824})^3(1O^{24}) = 22.59\ \frac{g}{cm^3}$$ (7 pts)

ANSWER IS: 22.59

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

$$\frac{cm^3}{mol} = (\frac{cm^3}{g})(\frac{g}{mol}) = (\frac{1}{22.59})(19O.2) = 8.42\ \frac{cm^3}{mol}$$

ANSWER IS: 8.42

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)

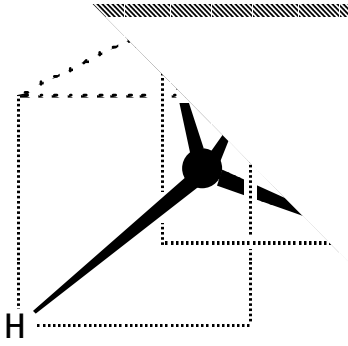
i) $\underline{I}F_4^+$ sp^3d/ seesaw

ii) $\underline{S}F_5^+$ sp^3d/ trigonal bipyramid

iii) $\underline{N}F_4^-$ CNE

iv) $\underline{B}F_4^+$ CNE

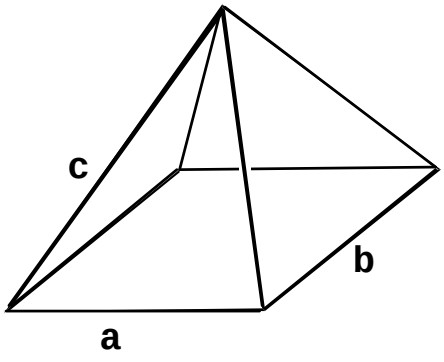
8) State how many of each of the following types of elements of symmetry exist in chlorofluoromethane. (8 pts)



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 symmetry, 0

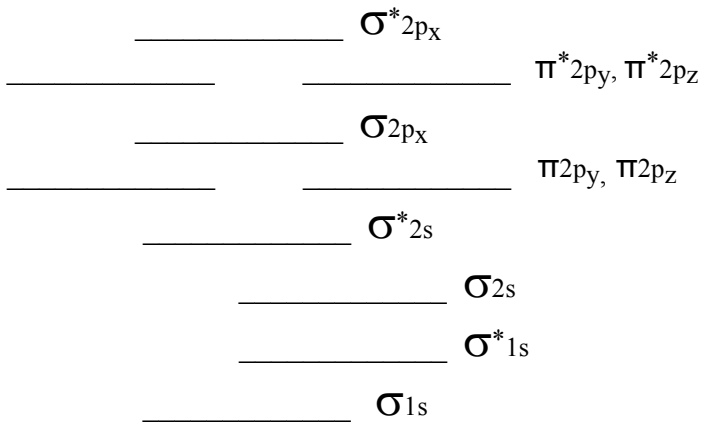
two fold axis of rotation, 0

three fold axis of rotation, 0

four fold axis of rotation, 1

planes of symmetry, 4

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	3	2	1
Bond Length		<	<
Bond enthalpy		>	>
Number of unpaired electrons	O	O	2

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 = O

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

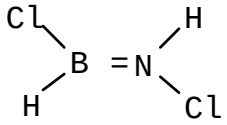
$$F_2 < Li_2 < Ne_2^+$$

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)

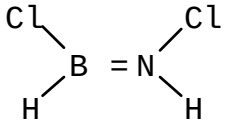
F-H > O-H > C-H

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) $8.48x10^{-19}$ ii) $4.97x10^{-19}$ iii) $3.52x10^{-19}$ iv) $2.67x10^{-19}$

$\varepsilon\ (\frac{J}{molecule}) = (\frac{kJ}{mol})(\frac{J}{kJ})(\frac{mol}{molecule}) = (511\text{-}212)(1O^3)(\frac{1}{6.O22x1O^{23}})$

GIVE 4 pts FOR EITHER i or iii ANSWER IS: ii

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) O > K > S

ACTUAL VALUES (kJ): 147 133 98

16) List the following in order of decreasing radius.

Na^+, Mg^+, and K^+. (6 pts) $Mg^+ > K^+ > Na^+$

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) $N^{3-} < S^{2-} < P^{3-}$

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

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

2O) List the following atoms in order of decreasing 3rd ionization energy. Li, Na, and Al (6 pts) Li > Na > Al
ACTUAL VALUES (kJ): 510 301 117

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

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 436 C-H 412 C-O 36O N-N 163

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

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

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

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