Exam II: Chemistry 4610/5560 Inorganic Chemistry Fall, 2001 Department of Chemistry University of North Texas Dr. Mohammad Omary

## Student Name:

1) Construct molecular orbital schemes to describe the	he bonding in the following diatomic species:
	(0.1

(24 points)

a) O <sub>2</sub>	c) CN
b) HF	d) $[Cr^{2+}]_2$
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b) HF	d) [Cr <sup>2+</sup> ] <sub>2</sub>
b) HF	d) [Cr <sup>2+</sup> ] <sub>2</sub>
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2) For each of the molecules in Question 1, determine the following:

a) bond order O <sub>2</sub> :	c) the symmetry of the HOMO and LUMO O <sub>2</sub> : HOMO= LUMO=	
HF :	HF : HOMO=	LUMO=
$CN^{-}$ :	CN <sup>-</sup> : HOMO=	LUMO=
$[Cr^{2+}]_2$ :	$[Cr^{2+}]_2$ : HOMO=	LUMO=

b) spin multiplicity  $O_2$ :

HF:

 $CN^{-}$ :

 $[Cr^{2+}]_2$ :

3) For each of the following pairs of atomic orbitals, determine whether a bonding molecular orbital may form as a result of their interaction. If so, sketch that bonding molecular orbital and identify whether it is a ?, ?, or ? orbital. Always assume that the bonding axis is the *z*-axis.

a)  $p_x, p_x$ 

(8 points)

(12 points)

b) *s*, *p*<sub>z</sub>

c)  $d_{xz}$ ,  $p_x$ 

d) 1*s*, 5*s* 

4) Construct a reasonable molecular orbital scheme to describe the bonding in the planar molecule BH<sub>3</sub>. (18 points)

5) Determine the effect of the following processes on the strength of B-H bonds in  $BH_3$  (i.e., determine whether each process leads to strengthening, weakening, or no change in the B-H bonds).

a) Oxidation to form a cation:

(6 points)

b) Reduction to form an anion:

c) Light absorption to form an exciton:

6) Arrange the following and give a brief explanation:

(20 points)

a) Relative acidity among HF, HCl, HBr, and HI:

b) Relative acidity among HClO, HClO<sub>2</sub>, HClO<sub>3</sub>, and HClO<sub>4</sub>:

c) Relative acidity among SnH<sub>4</sub>, SbH<sub>3</sub>, and TeH<sub>2</sub>:

d) Relative basicity with B(C<sub>2</sub>H<sub>5</sub>)<sub>3</sub> among pyridine, 2-ethylpyridine, 4-ethylpyridine, and 4-fluoropyridine:

e) Relative solubility among PbCl<sub>2</sub>, PbBr<sub>2</sub>, and PbI<sub>2</sub>:

7) Refer to the figure on the next page that shows the HOMO and LUMO for various species and then predict the reaction of water with:

a) calcium metal

b) Cl<sup>-</sup>

c) Mg<sup>2+</sup>

d) F<sub>2</sub>

**Bonus question:** Aqueous solutions of the following oxides lead to the formation of hydroxide species (M-O-H). The resulting  $B_2O_3$  solutions are acidic,  $Sc_2O_3$  solutions are basic, while  $Al_2O_3$  solutions are amphoteric (i.e., have both acidic and basic properties). Explain.

(6 points)

(12 points)