CHM151Y CHEMISTRY: THE MOLECULAR SCIENCE
INORGANIC CHEMISTRY SECTION

TEST #2: FEBRUARY 10, 2025
12:10 – 1:00 p.m.
Prof. John De Backere

INSTRUCTIONS: The test time is fifty minutes. Please fill in your name, student number, **and TWO DIGIT lab demonstrator group** (where your marked exam will be returned) below. Molecular model kits and calculators are allowed. No other aids are permitted. When instructed to begin, you should write your initials at top of each page of the exam. **Read the instructions for each problem carefully.** Write your answers on the examination sheet in the space provided and use the back of each sheet for any rough work. Only answers written in pen will be considered for re-grading. A periodic table has been included on the last page.

DO NOT LOOK AT THE OTHER TEST PAGES UNTIL INSTRUCTED TO BEGIN

(LAST NAME, First name)	
Student number	**Laboratory Demonstrator Group # (two digits)**

Question	Total Marks Possible	Marks Awarded
1	5	
2	4	
3	8	
4	10	
5	15	
6	8	
Total	50	

Question 1. [5 marks]

(a) In the space provided below, write down a *possible* set of three quantum numbers for an atomic **5p orbital**.

n = _____ **l =** _____ **m_l =** _____

(b) How many radial nodes are there in this atomic orbital: _____

(c) How many angular nodes are there in this atomic orbital: _____

Question 2. [4 marks] Circle which of the following species you expect to have a larger radius, and provide a brief justification of your prediction using fundamental chemical principles:

K or **Ge** *Justification:* _____

_____

$[S]^+$ or $[S]^{2-}$ *Justification:* _____

_____

Question 3. [8 marks] For the nitrate anion, $[NO_3]^-$:

(a) Draw the most reasonable Lewis dot structure(s) including any resonance form(s), making sure to show all non-bonding (lone pairs) and formal charges where appropriate.

(b) Using VSEPR, the shape of this molecule is _____

(c) Predict the approximate bond angle: _____

(d) Would this molecule be polar or nonpolar: _____

(e) According to valence bond theory, what is the hybridization(s) of each atom in the molecule?

N : _____ O : _____

(f) What are the formal oxidation states of each atom in the molecule?

N : _____ O : _____

Question 4. [10 marks] Draw the Born-Haber cycle for the formation of barium difluoride from the elements, making sure to provide thermochemical equations for each step. Use the values provided in the table to calculate its lattice energy.

Step	ΔH^o / (kJ/mol)
ΔH^o_f $BaF_2(s)$	–1216
ΔH^o_{atom} Ba(s)	142
IE_1 Ba(g)	502
IE_2 Ba(g)	938
BE of $F_2(g)$	152
EA_1 of F(g)	–318
Lattice Energy	**?**

Question 5. [15 marks] (a) In the space provided, draw a complete and detailed molecular orbital diagram for the hypothetical diatomic boron oxide anion, **$[BO]^{2-}$**. For full marks, make sure to: **(i)** clearly draw and label the valence atomic orbitals considering their relative energies, **(ii)** draw all molecular orbitals indicating which atomic orbitals are combining and their relative phasing, and **(iii)** properly label every orbital.

(b) Label the **HOMO** and **LUMO** on your diagram above.

(c) What is the bond order for $[BO]^{2-}$: _____

(d) Do you expect it to be diamagnetic or paramagnetic: _____

Question 6. [8 marks] Predict the product formed in the following reactions including their state (s, l, g). Provide a brief rationale for your prediction and the expected state of matter. ***Note:*** *"x" indicates an excess of reagent, do not worry about balancing the equation just provide the product.*

(a) **B(s)** + *x* **Cl_2(g)** ⟶ **_____**

Justification(s): _____

_____

(b) **Pb(s)** + *x* **Br_2(g)** ⟶ **_____**

Justification(s): _____

_____

(c) **S_8(s)** + *x* **O_2(g)** ⟶ **_____**

Justification(s): _____

_____

(d) **Ba(s)** + *x* **H_2(g)** ⟶ **_____**

Justification(s): _____

_____

END OF TEST

USE THE SPACE BELOW FOR ROUGH WORK (IT WON'T BE MARKED)

1 **H** 1.008																	2 **He** 4.003
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.9	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.9	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (210)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 **Ac** (227)	104 **Rf** (263)	105 **Db** (262)	106 **Sg** (266)	107 **Bh** (267)	108 **Hs** (277)	109 **Mt** (268)	110 **Ds** (281)	111 **Rg** (272)	112 **Cn** (285)	113 (284)	114 (289)	115 (288)	116 (292)		118 (294)

58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (147)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
90 **Th** 232.0	91 **Pa** (231)	92 **U** 238.0	93 **Np** (237)	94 **Pu** (242)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

USE THE SPACE BELOW FOR ROUGH WORK (IT WON'T BE MARKED)