CHEM 310 Practice Exam 1B

Chemistry 310 **Name** _____

Practice Exam IB

Access ID (PSU Email) _____

There are 9 questions on this exam. Check that you have done all parts of all of the problems. The maximum score on this exam is 100 points.

Exam policy:

- **Calculators with text-programmable memory are not allowed.**
- **No outside materials, resources or papers are allowed, including scratch paper.**
- **A data sheet is attached to this exam**, along with scratch paper and a periodic table.
- The answer key will be posted on Canvas after the exam is graded.
- You have 75 minutes to complete this exam.
- Put your name and access ID on all pages in case they become separated.
- You must turn in all exam materials including scratch paper and data sheets.

Advice:

- As you read the question, underline or circle key words to highlight them for yourself. Avoid errors from "mis-reading" the question.
- Pay attention to units and magnitudes (decimal places) of numbers obtained from calculations.
- There is no penalty for guessing.

PERIODIC TABLE of the ELEMENTS

MAIN GROUPS 1A (1)	2A (2)	TRANSITION METALS 3B (3)	4B (4)	5B (5)	6B (6)	7B (7)	8B (8)	8B (9)	8B (10)	1B (11)	2B (12)	MAIN GROUPS 3A (13)	4A (14)	5A (15)	6A (16)	7A (17)	8A (18)
1 H 1.008																1 H 1.008	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180
11 Na 22.990	12 Mg 24.305	3	4	5	6	7	8	9	10	11	12	13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.066	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.867	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.845	27 Co 58.933	28 Ni 58.693	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.992	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc [98]	44 Ru 101.07	45 Rh 102.90	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La* 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po [209]	85 At [210]	86 Rn [222]
87 Fr [223]	88 Ra [226]	89 Ac** [227]	104 Rf [261]	105 Db [262]	106 Sg [266]	107 Bh [264]	108 Hs [265]	109 Mt [268]	110 Ds [271]	111 Rg [280]	112 Cn [285]	113 Nh [286]	114 Fl [289]	115 Mc [289]	116 Lv [293]	117 Ts [294]	118 Og [294]

* LANTHANOIDS	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm [145]	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
** ACTINOIDS	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np [237]	94 Pu [244]	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 [262]

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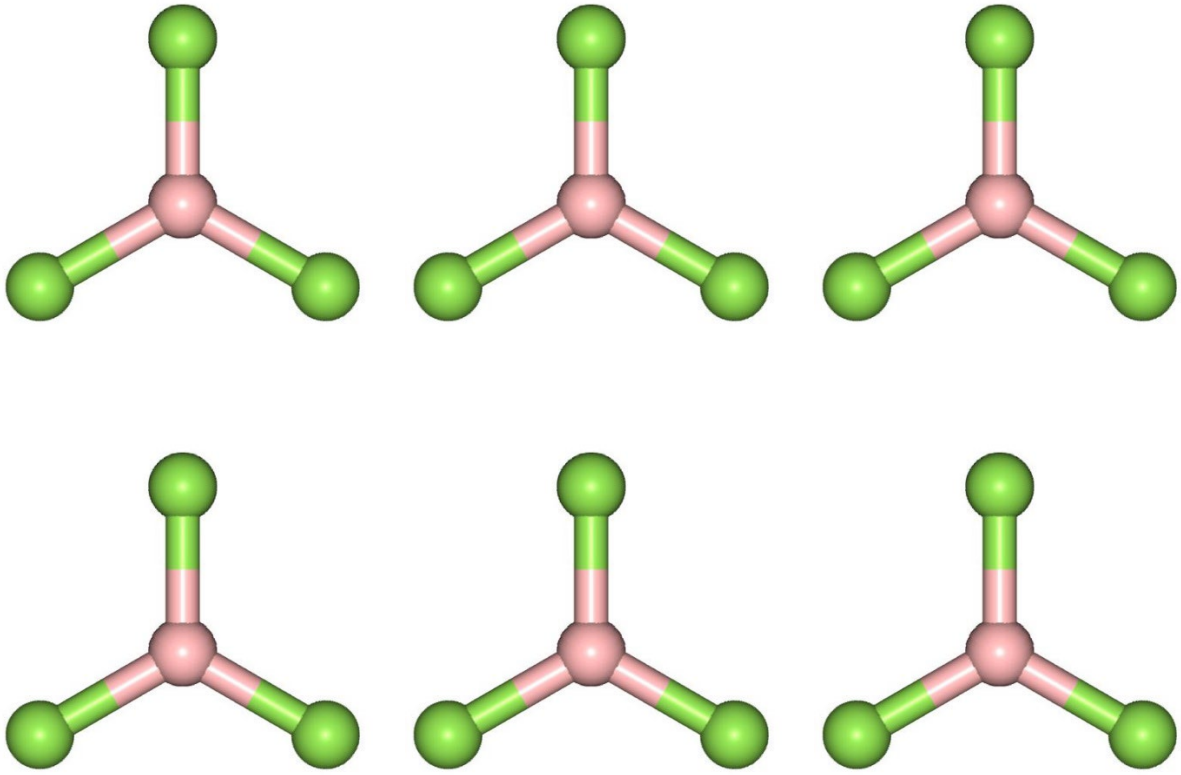
1. The structure of boron trifluoride, BF_3, is shown 6 times below (they are all the same).

a. Please **name and draw** the 6 different symmetry operations that can be performed on this molecule. If there is more than one axis or plane of the same name, draw ALL on the SAME drawing. (12 points)



b. Using the identified symmetry operations from Question 1 and the chart found on your data sheet, please identify the **point group of BF_3.** (3 points)

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2. Cobalt hydroxide is a pink insoluble powder. To synthesize such an interesting compound cobalt needs to be in a +2 oxidation state. (10 points)

a. Please write the electron configuration for Co^{2+}. (1 point)

b. Calculate the **effective nuclear charge** for a **3d** and a **4s** electron. (6 points)

3d	**4s**

c. Explain why the 4s electrons are removed before 3d electrons for the Co^{2+} cation. (2 points)

d. Which electron is more shielded? Which is more penetrating? (1 point)

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3. Using your knowledge of Lewis structures and VESPR theory, explain the differences in structure for the following pair: (5 points each)

a. **IF_2^-** is linear, however **H_2O** is not.

b. **CCl_4** has a different **bond angle** than **PH_3.** Identify which molecule has a larger bond angle and why.

4. For **ICl_2^-:**

a. Please draw the resonance structures for **ICl_2^-** and resultant composite octet structure (5 points)

b. Please calculate the bond order of the I-Cl bond and the corresponding formal charges for the composite octet structure. (5 points)

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5. Which symmetry operation(s) when performed sequentially result in the identity (E) operation? Circle all that apply. (6 points)

σ_v^2	$\sigma_v \cdot \sigma_h$	C_1
C_4^2	S_2	S_4^4

6. Please provide the formulas for five stable molecules and/or ions that are isoelectronic with **carbon monoxide**. (5 points)

7. Using the N-V method:

a. Please draw the composite octet structure and all relevant resonance forms for BF_3 (4 points)

b. Does BF_3 experience no-bond resonance? Circle one. (1 point) **YES** **NO**

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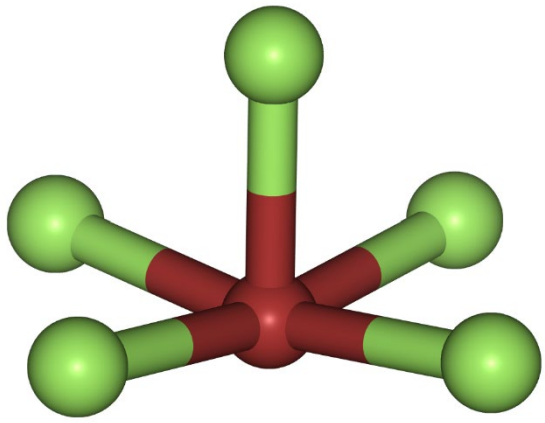
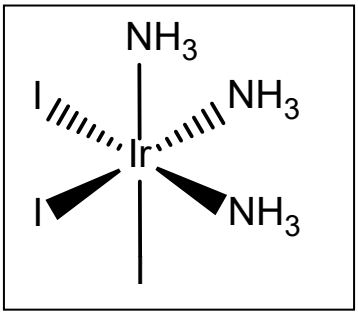
8. Given the following character table, identify the symmetry species that transforms the same as the p_z orbital in BrF_5 (pictured to the right). Assign the z-axis to be collinear with the principal axis of rotation. Please circle your answer. (5 points)

C_{4v}	E	$2C_4$ (z)	C_2	$2\sigma_v$	$2\sigma_d$
A_1	+1	+1	+1	+1	+1
A_2	+1	+1	+1	-1	-1
B_1	+1	-1	+1	+1	-1
B_2	+1	-1	+1	-1	+1
E	+2	0	-2	0	0



9. The structure of *fac*-triamminetriiodoiridium is shown to the right.



a. What principal rotation axis does it have? Circle one. (5 points)

C_1	C_2	C_3	C_4	C_6

b. Which mirror plane can the molecule reflect over and be the same, if any? Circle one. (5 points)

σ_d	σ_h	σ_v	NONE

c. Does the molecule have an inversion center? Circle one. (2 points) **YES** **NO**

d. Does the molecule have an improper rotation axis? (2 points) **YES** **NO**

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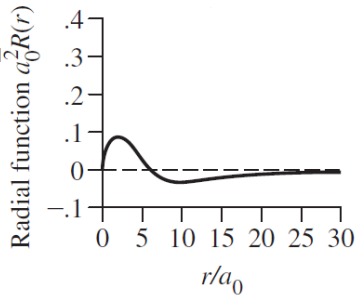
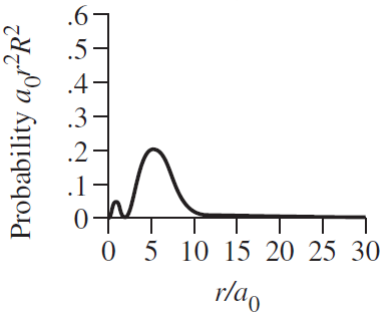
10. Indicate which orbital (such as 1s, 2p, 4d, etc.) that each picture, description, or plot below corresponds to. If the picture, description, or plot could correspond to more than one orbital, list all possibilities. Do NOT distinguish between orbital subscripts of x, y, z, etc. Your answers do not need subscripts on the orbital, or descriptions of the spatial orientation. (20 points)

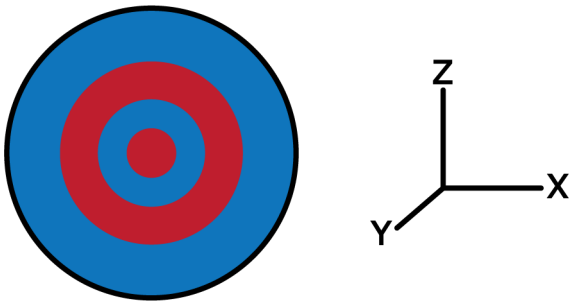
a.



b.



c.



d.

***n* = 6, ℓ = 3, m_ℓ = -2, m_s = +1/2**

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CHEM 310 Data Sheet

Conversions and Constants

$1\ g = 6.02 \times 10^{23}\ amu$

$1\ \text{Å} = 1 \times 10^{-10}\ m$

$1\ eV = 96\ kJ\ mol^{-1}$

$for\ 1\ eV\ \lambda = 1240\ nm$

$1\ kcal = 4.184\ kJ$

$1\ J = C \cdot V = kg\ m^2 s^{-2}$

$1\ A = Cs^{-1}$

$c = 2.99792458 \times 10^{8}\ m\ s^{-1}$

$h = 6.63 \times 10^{-34}\ J\ s$

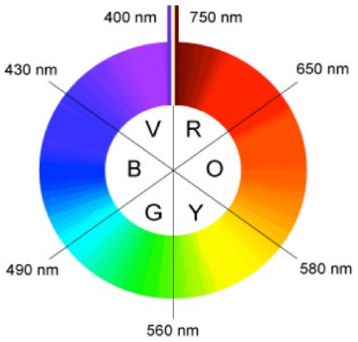
$F = 96485\ C\ mol^{-1}$

$N_A = 6.022 \times 10^{23}\ mol^{-1}$

$R = 8.314\ Jmol^{-1}K^{-1}$

$K_w = 1.0 \times 10^{-14}\ at\ 298\ K$

Color Wheel with λ Ranges



Equations

same group; 0.35
(*n*-1 group); 0.85
(lower *n* groups); 1.00

S for *nd/nf*
same group; 0.35
(groups to left); 1.00

$Z_{eff} = Z - S$

D(n) = D(m) – 0.6 log(n/m)

slope = 0.0592 V/pH

$-\Delta H = E_A E_B + C_A C_B + W$

$\mu_s = [n(n+2)]^{\frac{1}{2}}\ \mu_B$

$O_pE(OH)_q$ pK_a ~ 8 – 5p
add 5 units for q > 1

$\Delta G° = -nfE° = -RTlnK$

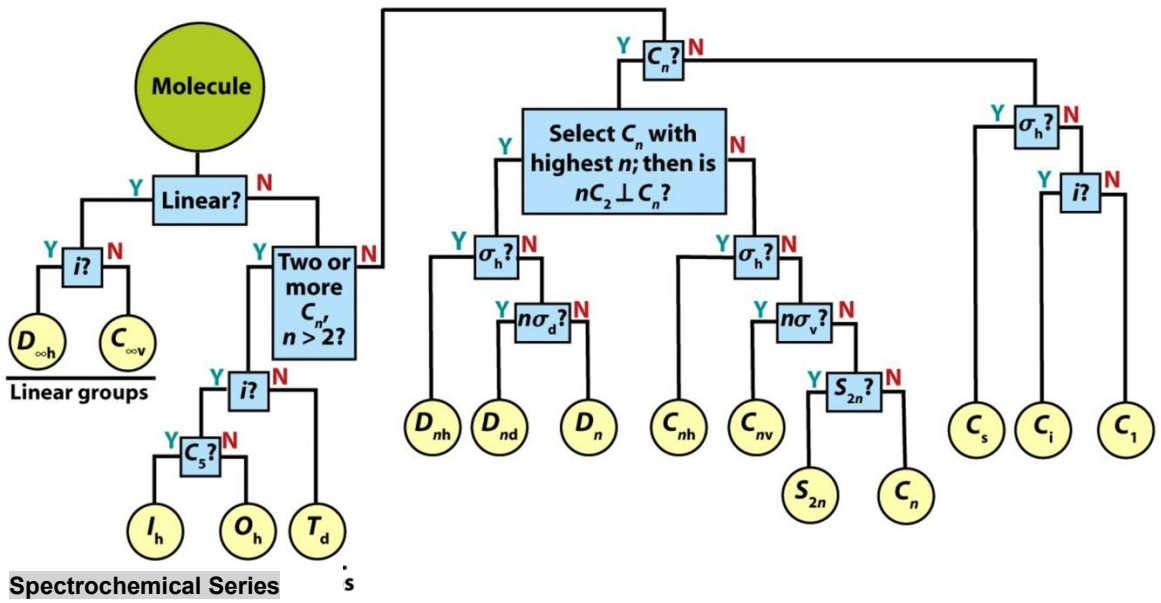
$E° = \frac{0.0592}{n} \log K\ (@298K)$

$E = E° - \frac{0.0592}{n} log\ Q(@298K)$

$E = h\nu = \frac{hc}{\lambda}$

$E_g(eV) = \frac{1240}{\lambda(nm)}$

Point Group Flow Chart



Spectrochemical Series

$I^- < Br^- < S^{2-} < \underline{S}CN^- < Cl^- < NO_2^- < N^{3-} < NO_3^- < F^- < OH^- < C_2O_4^{2-} < O^{2-} < H_2O <$
$\underline{N}CS^- < CH_3CN <$ pyridine $< NH_3 <$ en $<$ bipy $<$ phen $< NO_2^- < PPh_3 < CN^- < CO$

Trans-directing ligands

$F^-, H_2O, OH^- < NH_3 <$ py $< Cl^- < Br^- < I^-, SCN^-, NO_2^-, SC(NH_2)_2, Ph^- < SO_3^{2-} < PR_3,$
$AsR_3, SR_2, CH_3^- < H^-, NO, CO, CN^-, C_2H_4$