Chemistry 310 **Name** _____

Practice Final Exam II

Spring 2020 **Access ID (PSU Email)** _____

There are 16 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)	3A (13)	4A (14)	5A (15)	6A (16)	7A (17)	MAIN GROUPS 8A (18)
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	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	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]

CHEM 310 SPRING 2020 Practice Exam 1

Name _____ Access ID email

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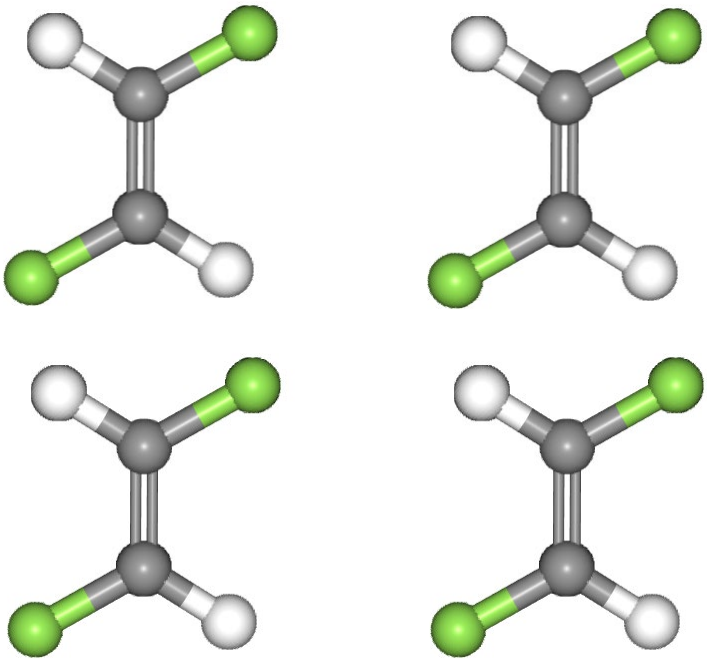
1. The structure of *trans*-1,2-difluoroethylene is shown 4 times below (they are all the same).

a. Please **name and draw** the 4 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. (4 points)



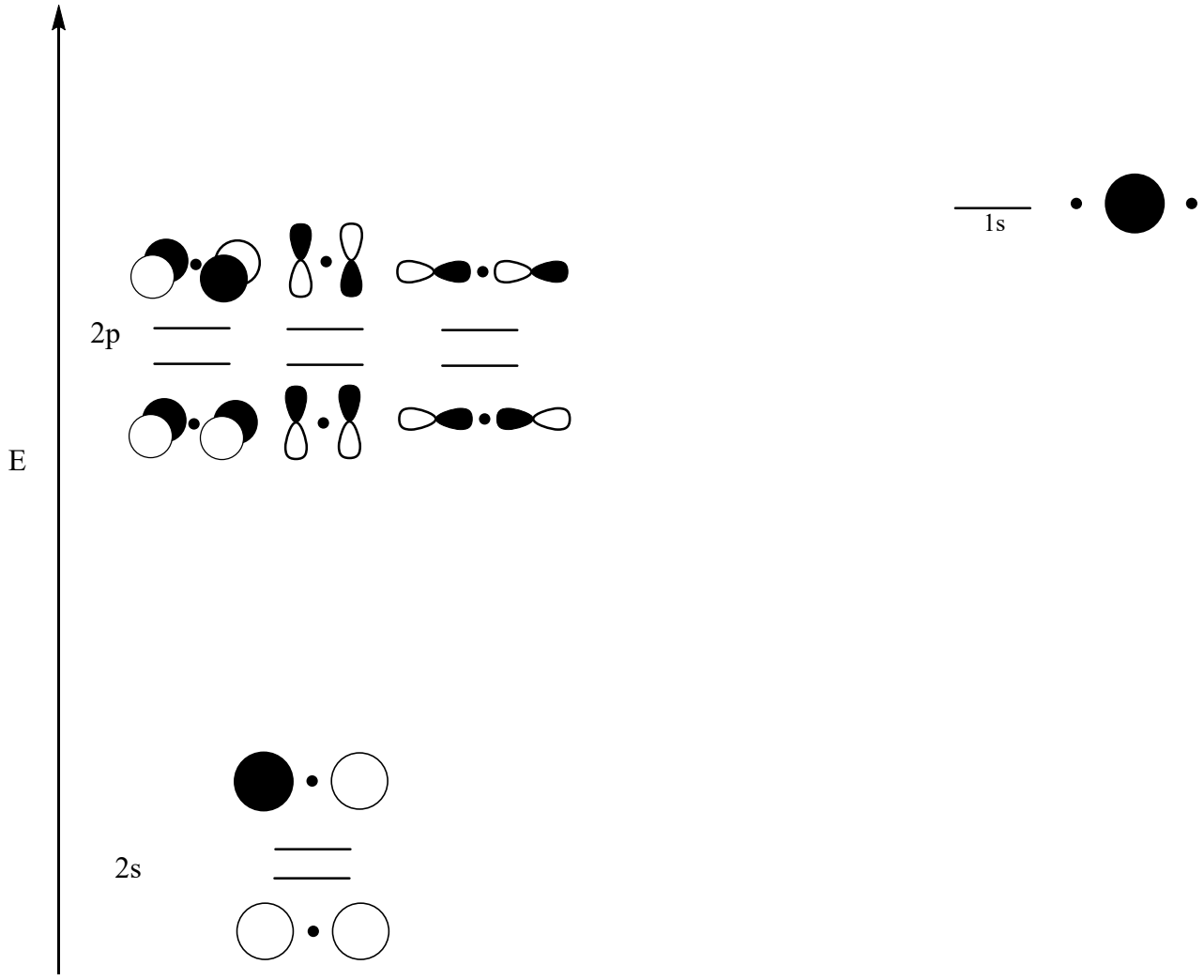
b. Using the identified symmetry operations from Question 1 and the chart found on your data sheet, please identify the **point group of *trans*-1,2-difluoroethylene.** (2 points)

2. Draw the complete molecular orbital diagram for the linear triatomic molecule FHF^- in the space below. A template is provided.

a. Construct a molecular orbital diagram for the F-H-F^- molecule. Use short lines to represent the molecular orbitals at their approximate energy levels relative to the atomic orbitals shown below. Assume F-F 2p and 2s **atomic orbitals** are degenerate. (3 points)

b. Label and draw the 3-dimensional shapes of all molecular orbitals, indicate which orbital line they belong to, and clearly indicate which molecular orbitals are sigma, pi, gerade, ungerade bonding, antibonding, and non-bonding. Use a dot to represent a node, similar to the one shown in the fluorine group orbitals. (4 points)

c. Fill in the molecular orbital diagram you drew with the appropriate number of electrons at the correct locations. (2 points)

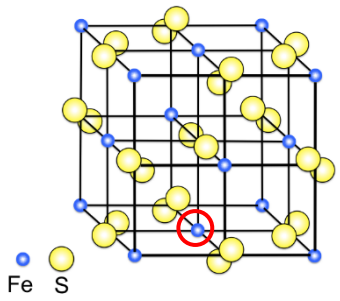


Two F atoms **F-H-F⁻ Molecule** One H atom

d. Calculate the bond order using your MO diagram. (1 points)

3. Please answer the following questions regarding pyrite (FeS_2). Pyrite is a crystal structure **similar (not the exact same)** to that of NaCl.

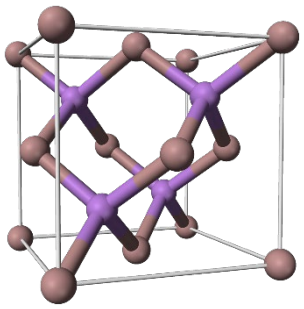
a. What is the **coordination number** of Fe? (2 points)



b. What is the fractional coordinate for the atom circled in RED. (3 points)

(0, 0, 0)	(½, ½, 0)	(½, 0, ½)	(0, ½, ½)	(½, ½, ½)

4. Gallium arsenide is a semiconductor. Given the unit cell of GaAs, please answer the following questions. Gallium is represented by the pink atoms, while Arsenide are the purple atoms.



a. Which atom is the packing atom? (1 point)

Ga^{3+} OR As^{3-}

b. Please draw the 2-dimensional projections that show the layers of the cell. Provide a key for the different atoms. (5 points)

c. How many interstitial holes are filled? What type are they? (4 points)

8 tetrahedral	4 octahedral	2 octahedral; 2 tetrahedral	4 tetrahedral

d. What type of semiconductor is GaAs? (3 points)

n-type p-type undoped interstitial

5. Please explain the following phenomena using periodic trends/electron configuration to support your answers.

a. Zirconium and Hafnium have similar atomic and ionic radii but differ in their atomic masses and electron counts. (5 points)

b. Oxygen has a smaller first ionization energy than nitrogen even though oxygen's valence electrons experience a larger effective nuclear charge. (5 points)

6. Draw the DOS (density of states) diagrams for Au and Si. Include the Fermi level and the band gap and indicate which part of the diagram has orbitals filled with electrons. Label each diagram with the appropriate element and the axes. Which of these elements is a better conductor and why? (4 points)

7. Which one of the following semiconductors will appear black? (3 points)

A. Fe_2O_3, $E_g = 2.2$ eV

B. TiO_2, $E_g = 3.0$ eV

C. GaAs, $E_g = 1.4$ eV

D. AgI, $E_g = 2.8$ eV

E. CdS, $E_g = 2.6$ eV

8. For each complex below please identify the oxidation state, d-electron count, the molecular shape, and a diagram illustrating d-splitting.

a. $[NiCl_4]K_2$ (4 points)

b. $[Ni(CN)_4]K_2$ (4 points)

9. Please rationalize the differences in formation constants for the pair of reactions. (4 points)

$Au^+ (aq) + 4\ CN^- (aq) \rightleftarrows [Au(CN)_4]^-$ $\quad K_f = 1.00 \times 10^{56}$

$Au^+ (aq) + 4\ Cl^- (aq) \rightleftarrows [Au(Cl)_4]^-$ $\quad K_f = 1.00 \times 10^{26}$

10. Xenon difchloride, $XeCl_2$, is a the only known stable xenon-chloride compound. Using the N-V method:

a. Please draw **all relevant resonance forms** for XeF_2. Include formal charges and lone pairs. (4 points)

b. Please draw the composite octet structure for XeF_2. Include averaged formal charges, lone pairs, and 3-dimensional molecular geometry (i.e wedges). (3 points)

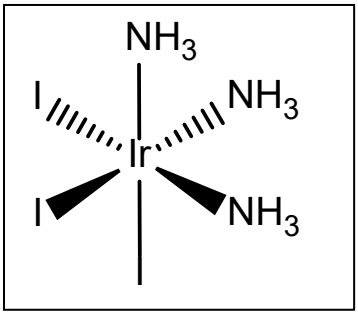
c. What is electron **group geometry**? What is the **molecular geometry**? (4 points)

11. Based on the Latimer diagram below, please answer the following question:

$$\overset{+5}{V(OH)_4^{+}} \xrightarrow{\textbf{+1.00 V}} \overset{+4}{VO^{2+}} \xrightarrow{\textbf{+0.34 V}} \overset{+3}{V^{3+}} \xrightarrow{\textbf{-0.26 V}} \overset{+2}{V^{2+}} \xrightarrow{\textbf{-1.13 V}} \overset{0}{V\ (s)}$$

a. Write a balanced reaction for the reduction of VO^{2+} to V(s) in acid. (4 points)

12. The structure of triamminetriiodoiridium is shown to the right.



a. What isomerization does this complex have? (3 points)

Linkage Isomer	**Geometric Isomer** ***(cis/trans)***	**Geometric Isomer** ***(fac/mer)***	**Optical Isomer**

13. Please answer the following questions regarding tungsten (0) hexacarbonyl.

a. What is the molecular formula of this compound? (1 point)

b. Calculate the CFSE of this complex include pairing energy if necessary. Do you expect it to be high spin or low spin? How does the pairing energy compare to Δ_o? (4 points)

c. What type of ligand is carbonyl? Circle one (1 point)

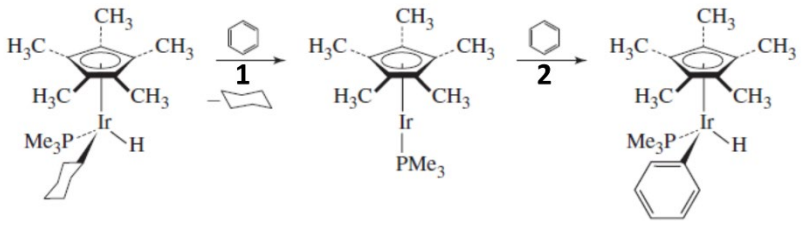
π-donor **π-acceptor**

d. Explain why CO is a strong field ligand. (2 points)

14. C-H bond activation with an iridium complex is shown below with each reaction step labeled with a number. Give the name of the process represented by each number, using the exact wording of one of the choices below for each answer. (4 points)

Word Bank

Orthometallation (*o*-LS)
Transmetallation (*trans*-LS)
Reductive Elimination (RE)
cis-trans Isomerization
Alkyl migration
Oxidative Addition (OA)
Migratory Insertion (1,2)



STEP 1	STEP 2

15. The base strength of ammonia depends on the solvent it is in. Explain the strength of ammonia when in water compared to when in acetic acid. Write the reactions between the solvent and solute to support your answers. (4 points)

16. Metal carbides and nitrides adhere to which crystal structure type? (3 points)

a. Zinc blende

b. Wurtzite

c. Nickel Arsenide

d. Sodium Chloride

e. Rutile