CHM 151Y CHEMISTRY: THE MOLECULAR SCIENCE INORGANIC CHEMISTRY SECTION

TERM TEST #3: February 13, 2023

PROF. D. W. STEPHAN

INSTRUCTIONS: The exam 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 are allowed. 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 test sheet in the space provided. Only answers written in pen will be considered for re-grading.

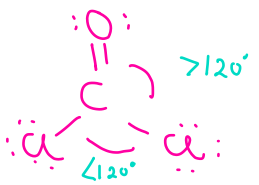
DO NOT LOOK AT THE OTHER TEST PAGES UNTIL INSTRUCTED TO BEGIN

(LAST NAME, First Name) Answers	
Student Number	**Demonstrator Group # (two digits)**

Question	Total Marks Possible	Marks Awarded
1	14	
2	8	
3	8	
Total	30	

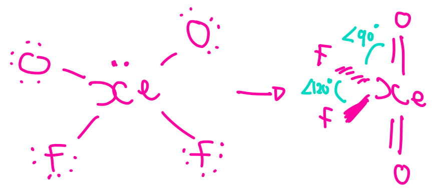
Question 1 (a). [8 marks]

Draw the Lewis dot structures for phosgene $C(O)Cl_2$ and XeO_2F_2 and label the geometry of the central atom. Using VSEPR theory, describe the perturbation from the ideal geometries in each case.



Trigonal planar

lone pairs on oxygen push the two Cl's together, causing the O=C–Cl bond angle to become greater than 120°, & the Cl–C–Cl bond angle to compress (less than 120°)



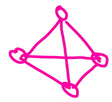
Seesaw geometry

The xenon lone pair will repel the lone pairs on F & O, causing the bond angles b/w the two F's & F & O to compress.

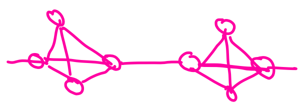
Question 1 (b). [6 marks]

List, describe and distinguish three allotropes of phosphorus.

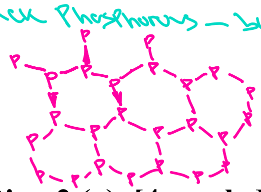
White Phosphorus – soft, waxy, most common allotrope



Red Phosphorus – hard, red, crystalline form of P. Not as common as white P.



Black Phosphorus – black, amorphous form. Least common allotrope



Question 2 (a). [4 marks]

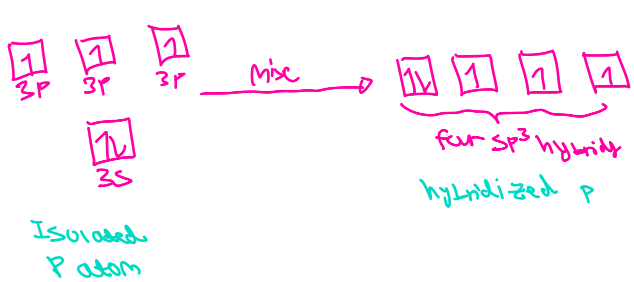
Use hybrid orbital diagrams, describe the mixing of the atomic orbitals of the central atom leads to hybrid orbitals in phosphorus trifluoride, PF_3.

Phosphorus has:

- 1 lone pair
- 3 bonds to fluorine

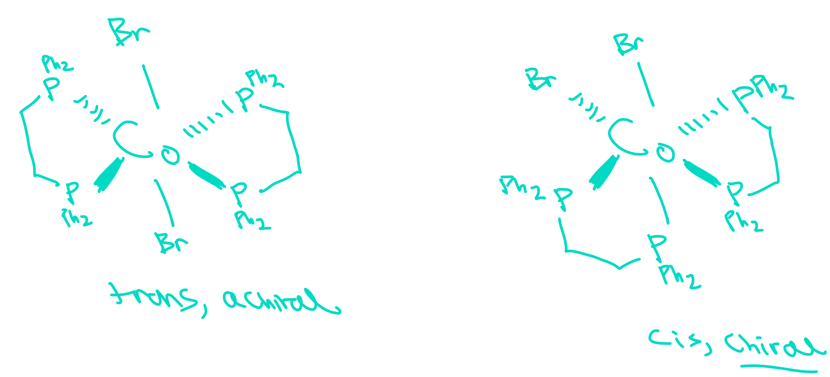
∴ Needs 4 orbitals total

It will use its 3s orbital & three 3p orbitals to yield four sp^3 hybridized orbitals



Question 2 (b). [4 marks]

Draw two isomers of six coordinate metal complexes, $(Ph_2PCH_2CH_2PPh_2)_2CoBr_2$. Label which is chiral and which is not.



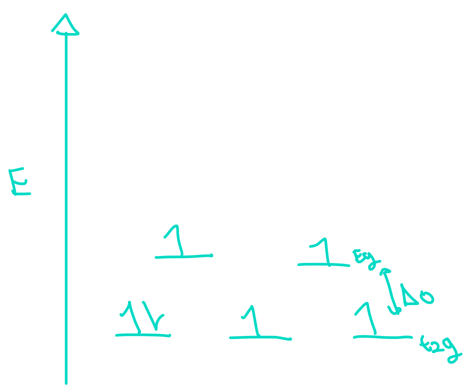
Question 3. [8 marks]

The two octahedral complexes $[Co(H_2O)_6]^{\cancel{2+}\,3+}$ and $[Co(CN)_6]^{\cancel{4-}\,3-}$ exhibit dramatically different magnetic properties. One is diamagnetic and the other is paramagnetic. Draw a d-orbital splitting diagram, predict the number of unpaired electrons and account for difference in the magnetic properties.

$[Co(H_2O)_6]^{3+}$

H_2O is a neutral ligand & is a mid-weak field ligand. ∴ will favor high spin complex

$Co(III) \rightarrow [Ar]\underbrace{3d^6}_{6\ d\ \text{electrons}}$



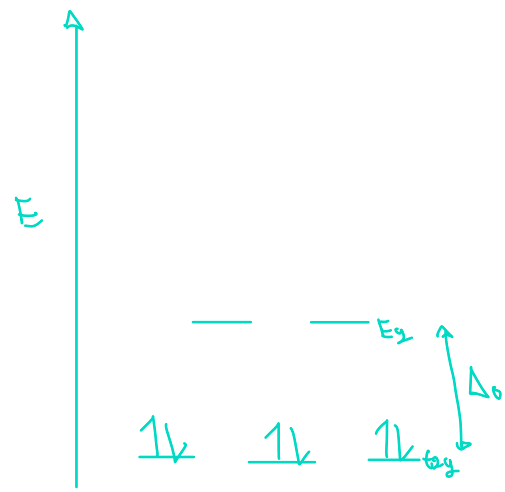
∴ Paramagnetic (has unpaired electrons)

$[Co(CN)_6]^{3-}$

↳ CN is an anionic ligand & strong field

↳ favors low spin

$Co(III) \rightarrow [Ar]3d^6$



∴ Diamagnetic (no unpaired electrons)

END OF TEST

Periodic Table of the Elements

1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 ←	9 VIIIB	10 →	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1 **H** 1.0079																1 **H** 1.0079	2 **He** 4.0026
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.179
11 **Na** 22.990	12 **Mg** 24.305											13 **Al** 26.982	14 **Si** 28.086	15 **P** 30.974	16 **S** 32.06	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.098	20 **Ca** 40.08	21 **Sc** 44.956	22 **Ti** 47.90	23 **V** 50.941	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.847	27 **Co** 58.933	28 **Ni** 58.70	29 **Cu** 63.546	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.922	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** 91.22	41 **Nb** 92.906	42 **Mo** 95.94	43 **Tc** [97.91]	44 **Ru** 101.07	45 **Rh** 102.905	46 **Pd** 106.4	47 **Ag** 107.868	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.69	51 **Sb** 121.75	52 **Te** 127.60	53 **I** 126.904	54 **Xe** 131.30
55 **Cs** 132.905	56 **Ba** 137.33	57-71 **La**	72 **Hf** 178.49	73 **Ta** 180.948	74 **W** 183.85	75 **Re** 186.21	76 **Os** 190.2	77 **Ir** 192.22	78 **Pt** 195.05	79 **Au** 196.966	80 **Hg** 200.59	81 **Tl** 204.37	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** [208.98]	85 **At** [209.99]	86 **Rn** [222.02]
87 **Fr** [223.02]	88 **Ra** [226.03]	89-103 **Ac**	104 **Rf** [265.12]	105 **Db** [268.13]	106 **Sg** [271.13]	107 **Bh** [270]	108 **Hs** [277.15]	109 **Mt** [276.15]	110 **Ds** [281.16]	111 **Rg** [280.16]	112 **Cn** [285.17]	113 **Nh** [284.18]	114 **Fl** [289.19]	115 **Mc** [288.19]	116 **Lv** [293]	117 **Ts** [294]	118 **Og** [294]

Lanthanides	57 **La** 138.905	58 **Ce** 140.12	59 **Pr** 140.907	60 **Nd** 144.24	61 **Pm** [145]	62 **Sm** 150.4	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.925	66 **Dy** 162.50	67 **Ho** 164.930	68 **Er** 167.26	69 **Tm** 168.934	70 **Yb** 173.04	71 **Lu** 174.967
Actinides	89 **Ac** [277.03]	90 **Th** 232.038	91 **Pa** 231.035	92 **U** 238.029	93 **Np** [237.05]	94 **Pu** [244.06]	95 **Am** [243.06]	96 **Cm** [247.07]	97 **Bk** [247.07]	98 **Cf** [251.08]	99 **Es** [252.08]	100 **Fm** [257.10]	101 **Md** [258.10]	102 **No** [259.10]	103 **Lr** [262.11]