Name Mr. Perfect Date F 11

1. Using the spectrochemical series, fill the electrons in the following crystal field diagram for the following square planar complex. Is this complex high spin or low spin? Also predict is the compound is paramagnetic or diamagnetic. (15 pts)

Spectrochemical Series

$I^- < Br^- < Cl^- < F- < OH^- < H_2O < NH_3 < en < NO_2^- < CN^- < CO$

Weak field (high spin) Strong field (low spin)

$[Ni(CN)_4]^{3+}$

**Square Planar**

$Ni^{7+}$

$d^3$ ion

___ $d_{x^2-y^2}$

___ $d_{xy}$

CN⁻ low spin

___ $d_{z^2}$

paramagnetic

_↓↑_ $d_{xz}$ _↑_ $d_{yz}$

2. The complex ion $[Fe(CN)_6]^{2+}$ is red in solution. Calculate the crystal field splitting energy in kJ/mol for this ion. (10 pts)

$h = 6.626 \times 10^{-34}$ Js

$c = 3.00 \times 10^{8}$ m/s

$6.02 \times 10^{23}$ ion/mol

1 nm = $10^{-9}$ m

| Absorbed wavelength (nm) | Observed Color |
|---|---|
| 400 violet | greenish-yellow |
| 450 blue | yellow |
| 490 blue-green | red |
| 570 yellow-green | violet |
| 580 yellow | dark-blue |
| 600 orange | blue |
| 650 red | green |

$$\Delta = E = \frac{hc}{\lambda} = \frac{(6.626x10^{-34} J\ s)(\frac{3.00x10^{8} m}{s})}{(490\ nm)(\frac{10^{-9} m}{nm})} \times \frac{6.02x10^{23} ion/mol}{1000\ J/kJ} = 244.2\ kJ/mol$$

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3. Balance the following reactions using the half-reaction method: (10 pts)

a) $Cu + HNO_3 \rightarrow Cu^{2+} + NO$ [acidic solution]

$$2 \text{ x } (Cu \rightarrow Cu^{2+} + 2e^-)$$
$$\underline{3 \text{ x } (3e^- + 3H^+ + HNO_3 \rightarrow NO + 2H_2O)}$$
$$6H^+ + 3Cu + 2HNO_3 \rightarrow 3Cu^{2+} + 2NO + 4H_2O$$

b) $NO_2^- + Al \rightarrow NH_3 + AlO_2^-$ [basic solution]

$$6e^- + 7H^+ + NO_2^- \rightarrow NH_3 + 2H_2O$$
$$\underline{2 \text{ x } (2H_2O + Al \rightarrow AlO_2^- + 3e^- + 4H^+)}$$
$$OH^- + H_2O + NO_2^- + 2Al \rightarrow NH_3 + 2AlO_2^-$$

4. State the oxidation number and the coordination number of the transition metals for each of the following compounds. (10 pts)

a) $K_2[NiCl_4]$

Coordination Number = 4
Oxidation Number = +2

b) $K_3[Fe(CN)_6]$

Coordination Number = 6
Oxidation Number = +3

c) $FeCl_3$

Coordination Number = 3
Oxidation Number = +3

d) $[Co(H_2O)_6]I_3$

Coordination Number = 6
Oxidation Number = +3

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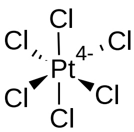
5. Draw the following transition metal complexes in their correct molecular geometry and state the hybrid orbital involved in the bonding. Name the molecular geometry shape and label the bond angles to receive full credit. (15 pts)

*Charges and ligands may not be correct due to the drawing program used.*

a) $K_4[PtCl_6]$

Bond Angles 90°



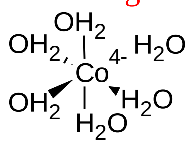
$4\ K^+$

Octahedral

$sp^3d^2$

b) $[Co(H_2O)_6]I_3$

Bond Angles 90°



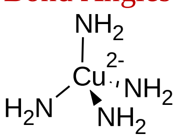
$3I^-$

Octahedral

$sp^3d^2$

c) $[Cu(NH_3)_4]SO_4$

Bond Angles 109.5°



$SO_4^{2-}$

Tetrahedral

$sp^3$

d) $[Ag(NH_3)_2]Cl$

Bond Angles 180°

$Cl^-$

Linear

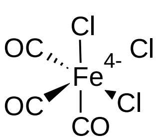
sp

6. Draw the isomers for the following compounds: (10 pts)

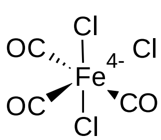
*Charges may not be correct.*

a. Geometric Isomers

$Fe(CO)_3Cl_3$



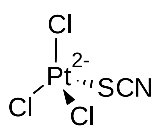
Fac Isomer



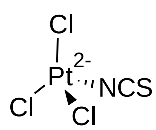
Mer Isomer

b. Linkage Isomers

$[PtCl_3(SCN)]^{2-}$



Thio linkage



Cyano linkage

7. Determine the oxidation and reduction half-reactions for the following galvanic cell. Clearly label which half-reaction occurs at the anode and which occurs at the cathode. Calculate $E°_{cell}$ (volts) and $\Delta G°$ (kJ/mol) for this cell. (10 pts)

F = 96500 J/V mol

| | Reduction Potentials | E° (V) | |
|---|---|---|---|
| Half-reactions: | $(Sn^{4+} + 2e^- \rightarrow Sn^{2+})x3$ | 0.15 | anode (oxidation) |
| | $(Au^{3+} + 3e- \rightarrow Au)x2$ | 1.50 | cathode (reduction) |

$E°_{cell} = E°_{red} - E°_{ox} = 1.50\ V – 0.15\ V = 1.35\ V$

$\Delta G° = -nFE°_{cell} = -(6mol)(96500J/Vmol)(1.35V) = -781.7\ kJ/mol$

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8. Complete and name the following nuclear equations: (10 pts)

a) $^{75}_{35}Br \rightarrow \,^{0}_{+1}e + \,^{75}_{34}Se$

positron emission

b) $^{103}_{46}Pd + \,^{0}_{-1}e \rightarrow \,^{103}_{45}Rh$ + x-ray

electron capture

c) $^{210}_{84}Po \rightarrow \,^{4}_{2}\text{He} + \,^{206}_{82}Pb$

alpha decay

d) $^{227}_{89}Ac \rightarrow \,^{0}_{-1}e + \,^{227}_{90}Th$

negatron emission

9. Calculate the emf for the following cell and determine if it is an electrolytic cell or a galvanic cell. (10 pts)

$$Cu_{(s)}/Cu^{2+}{}_{(aq)}//Zn^{2+}{}_{(aq)}/Zn_{(s)}$$

anode cathode

| Reduction Potentials | E° (V) |
|---|---|
| $Cu^{2+}$ $2e^- \rightarrow Cu$ | 0.34 |
| $Zn^{2+} + 2e^- \rightarrow Zn$ | -0.76 |

Electro Motive Force (emf) = $E°_{cell} = E°_{cat} - E°_{an}$ = -0.76 V – 0.34 V = -1.10 V

A negative $E°_{cell}$ will give a positive $\Delta G°$.

This cell is electrolytic.

10. (Extra Credit) Draw the polydentate ligand EDTA. (5 pts)

Ethylene Diamine TetraAcetate