Chem 130 – Third Exam

Name_____

On the following pages are eight questions that consider topics ranging from precipitation–solubility, acid–base, and oxidation–reduction reactions to metal–ligand complexes and coordination compounds. Read each question carefully and consider how you will approach it before you put pen or pencil to paper. If you are unsure how to answer one question, then move on to another question; working on a new question may suggest an approach to the one that is more troublesome. If a question requires a written response, be sure that you answer in complete sentences and that you directly and clearly address the question.

Question 1 _____/15

Question 2 _____/17

Question 3 _____/15

Question 4 _____/15

Question 5 _____/15

Question 6 _____/8

Question 7 _____/15

Total _____/100

Potentially useful equations and constants:

$c = \lambda\nu$

$E = h\nu = hc/\lambda$

$KE = h\nu - W$

$$\frac{1}{\lambda} = 1.09737\times10^{-2}\ \text{nm}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$FC_a = V_a - N_a - \frac{B_a}{2}$$

$$V \propto \frac{Q_+ Q_-}{d}$$

$$AVEE = \frac{xIE_s + yIE_p + zIE_d}{x + y + z}\ \text{(valence shell electrons only)}$$

$$\delta_a = V_a - N_a - B_a\left(\frac{EN_a}{EN_a + EN_b}\right)$$

$c = 2.998\times10^8$ m/s

$h = 6.626\times10^{-34}$ Js

$N_A = 6.022\times10^{23}$ mol^{-1}

Other potentially useful information is available as separate handouts.

Problem 1. For each pair of acids, circle the one that is the stronger acid and, in no more than 2–3 sentences each, explain the reason(s) for your choice. For the compounds in (b) and in (c), the acidic hydrogen is attached to oxygen.

(a) NH_4^+ vs. PH_4^+

(b) HOBr vs. HOI

(c) H_2CO_3 vs. HCO_3^-

Problem 2. The following information is known for reactions between the elements A, B, C, and D, and their +1 cations, A^+, B^+, C^+, and D^+; note that NR means there is no reaction:

(a) $C + B^+ \rightarrow C^+ + B$

(b) $C^+ + A \rightarrow NR$

(c) $A^+ + D \rightarrow NR$

(d) $D + B^+ \rightarrow D^+ + B$

Predict the products of the following two reactions, writing NR if there is no reaction.

(e) $D^+ + C \rightarrow$ (f) $A^+ + B \rightarrow$

In the space below, present a convincing argument that your responses are correct by arranging the cation/element pairs into a reactivity series ordered from the strongest oxidizing agent to the weakest oxidizing agent **and** explaining how you arrived at this order; in addition, explain why your reactivity series supports your predictions. Limit the written portion of your response to 3–6 sentences.

strongest oxidizing agent

weakest oxidizing agent

Problem 3. Suppose you have a solution that might contain one or more of the following cations:

Pb^{2+} Co^{2+} Fe^{3+} Ba^{2+} NH_4^+

To identify the ions in the solution you add HCl to the solution and observe a precipitate. After centrifuging, you remove the supernatant solution from the precipitate, add H_2SO_4 to this solution, and observe a precipitate. After centrifuging, you remove the supernatant from this second precipitate, add NaOH to this solution, and observe that no precipitate forms. In the table below, place each of the five cations in the cell that matches your prediction that it must be present, that it must be absent, or that you do not have sufficient information to determine if it is present or if it is absent.

cation must be present	cation must be absent	insufficient information

In the space below and in a short paragraph of 3–5 sentences, present a convincing argument that your assignments for all five cations are correct. Note: to receive full credit your explanation here must support your predictions.

Problem 4. The drug Nipride, $Na_2[Fe(CN)_5NO]$, is a metal-ligand complex that is used as a source of molecular NO during surgery where it helps moderate blood pressure. Although the compound releases molecular NO into the blood stream, it is present in the metal-ligand complex as the cation NO^+. When we first described a metal-ligand complex we characterized the metal in terms of its coordination valency and its ordinary valency. Using Nipride as an example, in 2-4 sentences, clearly explain the difference between these two types of valencies and report their values for the metal-ligand complex in Nipride.

The iron in this metal-ligand complex is expected to be low-spin due to the presence of the cyano and the nitrosyl ligands. How many unpaired electrons are in iron's *d*-orbials? Explain how you arrived at your response in 2-3 sentences.

Problem 5. Octahedral metal-ligand complexes of chromium (III) are quite colorful. For example, the following is a list of several such metal-ligand complexes and their colors.

$Cr(acac)_3$: red

$[Cr(H_2O)_6]^{3+}$: violet

$[CrCl_2(H_2O)_4]^{+}$: green

$[Cr(urea)_6]^{3+}$: green

$[Cr(NH_3)_6]^{3+}$: yellow

$Cr(CH_3CO_2)_3(H_2O)_3$: blue-violet

where the ligands are acetylacetone (written here in shorthand notation as acac), water, chloride, urea, ammonia, and acetate (which is $CH_3CO_2^-$). Arrange the ligands in order of increasing values for the octahedral field splitting, Δ_o. Explain how you arrived at your ordering in a paragraph of 4–6 sentences. Note: to receive full credit your explanation here must support your predictions.

Problem 6. Provide the chemical formula for the coordination compound that has the following name: hexamminecobalt(III) pentachlorocuprate(II).

Provide the name for the coordination compound that has the following formula: $(NH_4)_4[Fe(ox)_3]$ where "ox" is short for the oxalate anion, $C_2O_4^{2-}$.

Problem 7. Consider the hypothetical octahedral metal-ligand complex $MABC_2D_2$, which consists of the ligands A, B, C, and D. Draw all possible geometric isomers for this metal-ligand complex. Do not consider optical isomers. Be careful to draw only once each unique geometric isomer. There are more cells available to you in the table below then there are unique isomers.

You may use the space at the bottom of the page or on the back of this page to consider possibilities, but only those structures placed in the table will be evaluated. Be sure your structures are clear and easy to understand. If making a change to a structure makes it too messy, then place a large X through the structure and redraw it in a new cell.
