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 _____/12

Question 2 _____/16

Question 3 _____/12

Question 4 _____/12

Question 5 _____/12

Question 6 _____/12

Question 7 _____/8

Question 8 _____/16

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. Suppose you have a mixture that might contain any of the following cations as nitrate salts: Co^{2+}, Pb^{2+}, Ba^{2+}, K^+, and NH_4^+. To identify which cations are present, you run through the three tests described below.

(a) Placing a 1-mL portion of your mixture in a test tube, you add 10 drops of NaCl and observe that no precipitate forms.

(b) You add 10 drops of Na_2SO_4 to the contents of the test tube from (a) and observe that a precipitate forms.

(c) After centrifuging the contents of the test tube from (b), you transfer the supernatant to a clean test tube, add 10 drops of NaOH to the supernatant, and observe that a precipitate forms.

Based on these three tests, identify which of the five cations **must** be present in your mixture, which of the five cations **cannot** be present in your mixture, and for which of the five cations you **have insufficient** information to determine its presence or absence.

Problem 2. For each of the following pairs of compounds or ions, circle the one that is the stronger acid and explain the reason for your choice in 1-2 sentences each.

H_2Se or H_2Te

H_3PO_4 or H_3AsO_4

$HBrO_4$ or $HBrO_3$

CH_4 or NH_4^+

Problem 3. Platinum, Pt, is valuable because it is rare and because it is very unreactive and, therefore, very stable. In 800 A.D. the Islamic alchemist Jabir Ibn Hayyan discovered that although Pt will not dissolve in HCl or in HNO_3, it does dissolve in a mixture of the two acids as shown by the following oxidation-reduction reaction

$$2HNO_3(aq) + 6H^+(aq) + 3Pt(s) + 12Cl^-(aq) \rightarrow 2NO(g) + 3PtCl_4^{2-}(aq) + 4H_2O(l)$$

In the space below, identify all elements that change oxidation states and report their specific changes in oxidation state. What reactant is the oxidizing agent?

Problem 4. Quite a few years ago there was a local discharge of potassium permanganate, $KMnO_4$, a hazardous material that must be neutralized. Dave Roberts, storeroom manager and hazardous waste expert, treated the spill using sodium bisulfate, $NaHSO_3$. Knowing that K_a for $HMnO_4$ is 0.5 and that K_a for HSO_3^- is 6.4×10^{-8}, and using the handout on redox reactivity, which of the following reactions (unbalanced) was responsible for cleaning up the spill? Circle the correct reaction and explain the reason for your choice in 2-3 sentences.

acid–base: reaction $MnO_4^-(aq) + HSO_3^-(aq) \rightarrow HMnO_4(aq) + SO_3^{2-}(aq)$

redox reaction: $MnO_4^-(aq) + HSO_3^-(aq) \rightarrow Mn^{2+}(aq) + SO_4^{2-}(aq)$

Problem 5. The drug Nipride, $Na_2[Fe(CN)_5NO]$, is a coordination compound used to reduce blood pressure during surgery. The compound's anion is a metal-ligand complex where the ligands are the cyanide anion, CN^-, and the nitrosyl cation, NO^+. Using the iron in Nipride as an example, explain the difference between a metal's **ordinary (or primary) valen**cy and its **coordination (or secondary) valency**, limiting your response to 3-5 sentences. Be sure your reply includes the specific values for iron's ordinary valency and coordination valency.

Problem 6. As we saw during class, there are two coordination compounds with an empirical formula of $[Co(NH_3)_5NO_2]Cl_2$ because the nitrite anion, NO_2^-, can bind to cobalt through either its nitrogen or through one of its oxygens. The nitro complex is yellow in color and the nitrito complex is reddish-orange in color. In 3-4 sentences explain why the two compounds have different colors.

Problem 7. Provide the chemical formula for the coordination compound hexaminecobalt(III) pentabromocuprate(II).

Provide the name for the coordination compound $(NH_4)_4[Fe(ox)_3]$ where **ox** is a shorthand notation for the oxalate anion, $C_2O_4^{2-}$.

Problem 8. Draw all possible geometric isomers of the metal-ligand complex, $Co(NH_3)_3(NO_2)_3$, in which the nitrite ligands, NO_2^-, bind through their nitrogen only. Be careful to draw each possible geometric isomer just once.

The reaction of $Co(NH_3)_3(NO_2)_3$ with HCl yields the coordination compound $[Co(NH_3)_3(H_2O)Cl_2]Cl$ in which the two chlorides in the cation's metal-ligand complex are **trans** to each other. Assuming the NH_3 groups remain in place when $Co(NH_3)_3(NO_2)_3$ reacts with HCl, which of the geometric isomers for $Co(NH_3)_3(NO_2)_3$ that you drew above must react to form $[Co(NH_3)_3(H_2O)Cl_2]Cl$? Circle your choice and explain the reason for your choice in 1-3 sentences.