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 _____/12

Question 3 _____/12

Question 4 _____/12

Question 5 _____/12

Question 6 _____/6

Question 7 _____/17

Question 8 _____/17

Total _____/100

Potentially useful equations and constants:

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

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

$$FC_a = V_a - N_a - \frac{B_a}{2} \qquad V \propto \frac{Q_+Q_-}{d}$$

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

$$\delta_a = V_a - N_a - B_a\left(\frac{EN_a}{EN_a + EN_b}\right) \qquad c = 2.998\times10^8\ \text{m/s}$$

$$h = 6.626\times10^{-34}\ \text{Js} \qquad N_A = 6.022\times10^{23}\ \text{mol}^{-1}$$

Other potentially useful information is available as separate handouts.

Problem 1. The formation of a precipitate—or the lack thereof—is a common technique for identifying the presence or the absence of an ion in a sample. Suppose you have a solution that might contain one or more the following four cations: Ag^+, K^+, Ba^{2+}, and Cu^{2+}. To identify which ions are present in your sample, you carry out the following sequential set of tests. *First*, you add a solution of HCl to your sample and observe that a precipitate forms. *Second*, after centrifuging, you remove the supernatant solution, add to it a solution of H_2SO_4, and observe that nothing happens. *Finally*, you add a solution of Na_2CO_3 to the same supernatant solution and observe that a precipitate forms. Based on these three tests, identify which cations **must be present** in your sample, identify which **must be absent** in your sample, and identify for which cations you have **insufficient information** to reach a conclusion. For each cation, explain how you know that your conclusion is correct.

must be present	**must be absent**	**insufficient information**

Problem 2. For each of the following pairs of acids, circle the one that is the stronger acid and, for each pair, defend your choice in 1–2 sentences.

H_2S vs. HCl

PH_4^+ vs. NH_4^+

$HSeO_3$ vs. $HSeO_4$ (for both, hydrogen is bound to oxygen)

Problem 3. Some of the earliest matches were made by preparing a mixture of white phosphorous, P_4, and potassium chlorate, $KClO_3$, glued to the end of wooden stick. When rubbed across a piece of sandpaper, the oxidation-reduction reaction

$$3P_4(s) + 10KClO_3(s) \rightarrow 3P_4O_{10}(s) + 10KCl(s)$$

produced a flame. Draw a circle around the reactant that is the oxidizing agent. To support your answer, identify the specific element that is oxidized and the specific element that is reduced, and, for each, report the change in its oxidation state.

Problem 4. The following two reactions are known to occur:

$$Br_2(aq) + 2NaI(aq) \rightarrow I_2(aq) + 2NaCl(aq)$$

$$Cl_2(aq) + 2NaBr(aq) \rightarrow Cl_2(aq) + 2NaBr(aq)$$

Based on these observations, predict the products of the following reactions, writing NR if no reaction is expected.

$Cl_2(aq) + 2KI(aq) \rightarrow$

$Br_2(aq) + 2KI(aq) \rightarrow$

$Cl_2(aq) + I_2(aq) \rightarrow$

In the space below, defend your predictions in 2–5 sentences.

Problem 5. You can make a simple weather predictor by soaking a piece of filter paper in a solution of $CoCl_4^{2-}$ and letting the paper dry. On a sunny day with low humidity, the paper is pink due to the color of the tetrahedral $CoCl_4^{2-}$ metal-ligand complex. When the humidity increases—and the chance for rain increases—the paper turns blue as water molecules replace the chloride ions in $CoCl_4^{2-}$, forming the octahedral $Co(H_2O)_6^{2+}$ metal-ligand complex. The color in each case is the result of the splitting of cobalt's *d*-orbitals into two groups, one of higher energy and one of lower energy. The difference in energy is defined as Δ_o for an octahedral complex and as Δ_t for a tetrahedral. Based on the color of the two complexes, is the value for Δ_o bigger or smaller than that for Δ_t? Explain your reasoning in 1–3 sentences. *Note: The supplemental sheet shows the arrangement of d-orbitals for both an octahedral and a tetrahedral metal-ligand complex.*

Problem 6. What is the name for the coordination compound $[Co(NH_3)_5Cl](NO_3)_2$?

What is the formula for the coordination compound potassium diaquotetracyanochromate(II)?

Problem 7. The table below contains data for a series of coordination compounds. For each empty box, enter the missing information. If you wish, use the space below the table to explain how you arrived at your answers; although not required of you, I will review any notes you leave there.

	empirical formula	free chlorides	ordinary valence	coordination valency	number of ions	chemical formula
(a)	$PtCl_4(NH_3)_6$					$[Pt(NH_3)_6]Cl_4$
(b)	$PtCl_4(NH_3)_4$	2			3	
(c)	$PtCl_4(NH_3)_2$		+4		0	
(d)	K_2PtCl_6			6	3	
(e)	$KPtCl_3(NH_3)$	0	+2			
(f)	$Pt_2Cl_4(NH_3)_4$	0	+2/+2	4/4	2	

Problem 8. As a ligand, the nitrite ion, NO_2^-, can bind to a metal ion through its nitrogen (—NO_2) or through its oxygen (—ONO). With this in mind, draw all possible geometric and linkage isomers for the octahedral coordination compound $Pt(NH_3)_2(NO_2)Cl_3$, placing each unique isomer in a separate cell in the table below. Be sure to draw each unique isomer only once. There are more spaces in the table than there are unique isomers. If you wish, use the space below the table and/or the reverse side of this page to sketch out your ideas and/or to explain your approach; although not required of you, I will review any notes and/or sketches that you leave there.
