Chemistry 212 Key 4 Name: _____
Fall 2025 (Please print)

Multiple Choice (5 points each, Put answers in CAPS in the left margin.)
R = 8.314 J/mol•K $\mathcal{F}$ = 96,500 C/mol = 96,500 J/mol•V

1. For the slightly soluble salt $Pb(CN)_2$, adding which of the following would have the **largest** suppression of its solubility on a per mole of added material basis.

   A) HCl **B) NaCN** C) $Pb(NO_3)_2$ D) $Pb(NO_3)_4$

2. One way to help metal bridges last longer is to attach a wire to a block of zinc and the other end to the bridge. There is a strong flow of electrons from the zinc to the bridge to prevent the latter from rusting. At the same time, oxygen in the air is reduced to form zinc(II) oxide to balance the electron flow for the metal oxidation. In this situation,

   A) $\Delta G < 0, \Delta H < 0, \Delta S < 0$
   B) $\Delta G < 0, \Delta H > 0, \Delta S < 0$
   C) $\Delta G < 0, \Delta H < 0, \Delta S > 0$
   D) $\Delta G > 0, \Delta H > 0, \Delta S > 0$
   E) $\Delta G > 0, \Delta H < 0, \Delta S < 0$

3. Which of the following batteries is **not** rechargeable.

   A) The alkaline battery
   B) The nickel-cadmium battery
   C) The nickel metal hydride battery
   D) The lead-acid battery
   E) All are rechargeable

4. Consider the reaction: $2\ Al + 3\ Cu^{2+} \longrightarrow 2\ Al^{3+} + 3\ Cu$. How many moles (n) of electrons flow in this reaction?

   A) 1 B) 2 C) 3 D) 4 **E) 6**

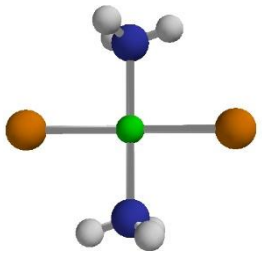
5. For the atoms and ions: Ag^+, Al^{3+}, Fe^{2+}, H^+, which is most easily reduced?

   A) Ag^+ B) Al^{3+} C) Fe^{2+} D) H^+ E) cannot tell from given information

0.80 V	$Ag^+ + e^- \rightarrow Ag$	-0.44 V	$Fe^{2+} + 2e^- \rightarrow Fe$
-1.66 V	$Al^{3+} + 3e^- \rightarrow Al$	0.00 V	$2\ H^+ + 2\ e^- \rightarrow H_2$

6. The geometry of this molecule is

   A) cis
   B) facial
   C) meridional
   D) trans



7. If one mole of $CrCl_3 \cdot 4NH_3$ reacts with $AgNO_3$ to produce one mole of AgCl(s), how can the formula $CrCl_3 \cdot 4NH_3$ be rewritten to show the proper coordination sphere?

A) $[Cr(NH_3)_4Cl_3]$ C) $[Cr(NH_3)_4Cl]Cl_2$
B) $[Cr(NH_3)_4Cl_2]Cl$ D) $[Cr(NH_3)_4]Cl_3$

8. How many different geometric isomers are possible for a metal (M) complex with the formula MA_2B_3C?

A) 1 B) 2 **C) 3** D) 4 E) 5

9. What is the oxidation number of cobalt in $[Co(NH_3)_5Cl](NO_3)_2$?

A) 1 B) 2 **C) 3** D) 4 E) 5

Discussion questions (You must show your work to receive credit!)

1. Consider the equilibrium $N_2O_{4\,(g)} \longrightarrow 2\,NO_{2\,(g)}$. $\Delta H^o = 57.9$ kJ/mol and $\Delta S^o = 176$ J/mol•K for this reaction. What are ΔG^o and K_p for the forward reaction. (T = 25 ºC) At what temperature does the equilibrium shift to the right? (10 points)

$\Delta G^o = \Delta H^o - T\Delta S^o$
$\Delta G^o = 57.9\ kJ \cdot mol^{-1} - (298\ K)(0.176\ kJ/mol \cdot K)$
$\Delta G^o = 5.45$ kJ/mol

$\Delta G^o = -RT\ln K_{eq}$
$5.45\ kJ/mol = (8.314\ J/mol \cdot K)(1\ kJ/1000\ J)(298\ K)\ln K_{eq}$
$\ln K_{eq} = -2.20$
$K_{eq} = 0.110$

The equilibrium shifts from left to right when $\Delta G^o = 0$.
$0 = (57.9\ kJ/mol)(1000\ J/kJ) - T(176\ J/mol \cdot K)$
$T(176\ J/mol \cdot K) = 57{,}900\ J \cdot mol^{-1}$
$T = 329\ K = 56\ ^oC$

2. Balance the following equation in basic solution by any method you choose. Show and label the balanced half-reactions in basic solution. (12 points, <u>partial</u> credit for balancing in acidic solution)

$SO_3^{2-}{}_{(aq)} + Cu^{2+}{}_{(aq)} \rightarrow SO_4^{2-}{}_{(aq)} + Cu^{+}{}_{(aq)}$

oxid: $[SO_3^{2-} + 2\ OH^- \rightarrow SO_4^{2-} + H_2O + 2\ e^-] \times 1$
redn: $[Cu^{2+} + e^- \rightarrow Cu^+] \times 2$

$SO_3^{2-} + 2Cu^{2+} + 2\ OH^- \rightarrow SO_4^{2-} + Cu^+ + H_2O$

3. In the electrolysis of $AlBr_3$, how much current is required to produce 0.50 mol bromine over a 75 min period? (6 points)

$2\ Br^- \rightarrow Br_2 + 2e^-$

$$\text{current} = \left(\frac{1\ A\bullet s}{C}\right)\left(\frac{1\ min}{60\ sec}\right)\left(\frac{1}{75\ min}\right)\left(\frac{96{,}500\ C}{mol}\right)(2\ mol)$$

$= 42.9\ A$

4. Consider the redox reaction $3\ Ag^+_{(aq)} + Al_{(s)} \rightarrow 3\ Ag_{(s)} + Al^{3+}_{(aq)}$. Using the data provided in multiple choice question #5, calculate E_{cell}^o and ΔG^o for the reaction. (8 points)

oxid:	$[Al \rightarrow Al^{3+} + 3\ e^-] \times 1$	$E_{oxid}^o = 1.66\ V$
redn:	$Ag^+ + e^- \rightarrow Ag] \times 3$	$E_{redn}^o = 0.80\ V$
	$Al + 3\ Ag^+ \rightarrow Al^{3+} + 3\ Ag$	$E_{cell}^o = 2.46\ V$

$\Delta G^o = -(3\ mol)(96{,}500\ J/mol\bullet V)(2.46\ V)(1\ kJ/1000\ J)$

$= -712\ kJ$

5. Provide formulas for the following names. (9 points)

potassium hexacyanochromate(III) – $K_3[Cr(CN)_6]$

hexaamminecobalt(III) chloride – $[Co(NH_3)_6]Cl_3$

diaquodichloroplatinum(II) – $Pt(H_2O)_2Cl_2$

6. What characteristic defines the difference between a transition metal and the other metals on the periodic table? (5 points)

Transition metals are defined as those having partially filled *d* orbitals.

7. Consider a molecule that is chiral. It will have two optical isomers. How are they related to each other? Name one of the two physical properties that differentiate them. Name both for a bonus. (5 points)

Chiral molecules are mirror images of each other. The differ in that they rotate plane polarized light in opposite directions, but by the same angle and they react with other chiral molecules differently.