Chemistry 212 Test 4 Name: _____
Fall 2022 (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. Which of the following processes is entropically unfavorable (for the system)?

   A) Boiling water
   B) Expanding a gas into a vacuum
   C) Making a hard-boiled egg
   D) Scattering seeds in the wind
   E) The burning of coal

2. How much $Mg(OH)_2$ (K_{sp} = 1.8 x 10^{-11}) will dissolve in 1.0 L of a 1.0 *M* HCl solution?

   A) 0.5 mol
   B) 1.0 mol
   C) 4.5 x 10^{14} mol
   D) 1.8 x 10^{15} mol
   E) 7.4 x 10^{17} mol

3. Which of the following is false about the lead storage battery?

   A) A lead plate is the cathode.
   B) Several cells are hooked together to increase cell potential.
   C) They are rechargable.
   D) Sulfuric acid is the solvent in the cell.
   E) All are true.

4. Which of the following would be an inert electrode?

   A) Ag B) Cu C) H D) Pt E) Zn

5. For the ions: Ag^+, Al^{3+}, Fe^{2+}, H^+, which is easiest to reduce?

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	$2\ H^+ + 2\ e^- \rightarrow H_2$

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

6. For which of the following geometries is a *trans* orientation not possible?

   A) Octahedral
   B) Square planar
   C) Tetrahedral
   D) Trigonal bipyramidal
   E) All may have a trans arrangement

7. On p. 1033 of your book, it says that titanium only forms compounds with oxidation numbers of 3+ and 4+, which is clearly incorrect. Which of the following is the principal oxidation number for titanium that the book missed?

   A) 0 B) +1 C) +2 D) +5 E) +6

8. Which of the following ions is least likely to form colored coordination complexes?

   A) Au^+ B) Co^{3+} C) Cr^{3+} D) Cu^{2+} E) Ni^{2+}

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

1. The formation constant of $[M(CN)_4]^{2-}$ is 3.42×10^{14}, where M is a generic metal. A 0.150 mole quantity of $M(NO_3)_2$ is added to a liter of 2.31 *M* NaCN solution. What is the concentration of M^{2+} ions at equilibrium? (10 points)

$$M^{2+}_{(aq)} + 4\ CN^-_{(aq)} \rightleftharpoons M(CN)_4^{4-} \qquad K_f = \frac{[M(CN)_6^{4-}]}{[M^{2+}][CN^-]^4}$$

	M^{2+}	CN^-	$M(CN)_4^{4-}$
initial	0.150 *M*	2.31 *M*	0 *M*
react	0 *M*	1.71 *M*	0.150 *M*
change	+x	+4x	-x
equil	x	1.71 + 4x	1.50 – x

$K_f = \frac{0.150 - x}{(x)(1.71+4x)^4} = 3.42 \times 10^{14}$

Because $K_f >> 1.71$, assume x is negligible

$3.42 \times 10^{14} = \frac{0.150}{(x)(1.71)^4}$

$x = 7.6 \times 10^{-16} \Rightarrow [M^{2+}] = 5.1 \times 10^{-17}\ M$

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)

$Au_{(s)} + O_{2\,(g)} + CN^-_{(aq)} \rightarrow Au(CN)_2^-{}_{(aq)} + H_2O_{2\,(aq)}$

oxid: $[Au + 2\ CN^- \rightarrow Au(CN)_2^- + e^-] \times 2$

redn: $[2\ H_2O + 2\ e^- + O_2 \rightarrow H_2O_2 + 2\ OH^-] \times 1$

$2\ Au + O_2 + 4\ CN^- + 2\ H_2O \rightarrow 2\ Au(CN)_2^- + H_2O_2 + 2\ OH^-$

3. For the half reactions: (12 points)

oxid: $[2Cl^- \rightarrow Cl_2 + 2e^-] \times 3$

redn: $[Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O] \times 1$

net: $Cr_2O_7^{2-} + 14H^+ + 6\ Cl^- \rightarrow 2\ Cr^{3+} + 7H_2O + 3\ Cl_2$

Calculate E^o_{cell}, ΔG^o, and K_{eq} for the net reaction at 25 ºC.

Standard Reduction Potentials in Aqueous Solutions at 25 °C

					Reduction Potential (V)
F_2	+ $2e^-$	→	$2F^-$		2.87
H_2O_2	+ $2H^+ + 2e^-$	→	$2H_2O$		1.78
MnO_4^-	+ $8H^+ + 5e^-$	→	$Mn^{2+} + 4H_2O$		1.51
Au^{3+}	+ $3e^-$	→	Au		1.50
Cl_2	+ $2e^-$	→	$2Cl^-$		1.36
O_2	+ $4H^+ + 4e^-$	→	$2H_2O$		1.23
$Cr_2O_7^{2-}$	+ $14H^+ + 6e^-$	→	$2Cr^{3+} + 7H_2O$		1.23
Br_2	+ $2e^-$	→	$2Br^-$		1.07
NO_3^-	+ $4H^+ + 3e^-$	→	NO + $2H_2O$		0.96

$E_{cell}^o = -1.36\ V + 1.23\ V = -0.13\ V$

$\Delta G^o = -(6\ mol_{e^-})(96{,}500\ \frac{J}{mol \cdot V})(0.13\ V)(\frac{1\ kJ}{1000\ J}) = -75.3\ kJ$

$E_{cell}^o = \left(\frac{(8.314\frac{J}{mol}\cdot K)(298\ K)}{(6\ mol)(96{,}500\ J/mol \cdot V)}\right)\ln K_C = \left(\frac{0.0592}{6}\right)\log K_C = -0.13\ V$

$\ln K_C = -30.4$ or $\log K_C = -13.5$

$K_C = 3.2 \times 10^{-14}$

4. Gallium is produced by the electrolysis of a solution made by dissolving gallium oxide in concentrated $NaOH_{(aq)}$. Calculate the mass of $Ga_{(s)}$ that can be deposited from a Ga(III) solution using a current of 0.210 A that flows for 20.0 min. (1 C = 1 A•s) (4 points)

$$\text{mass}_{Ga} = (0.210\ \text{A})\left(\frac{1\ \text{C}}{\text{A•s}}\right)(20.0\ \text{min})\left(\frac{60\ \text{sec}}{1\ \text{min}}\right)\left(\frac{1\ \mathcal{F}}{96{,}500\ \text{C}}\right)\left(\frac{1\ \text{mol}_{Ga}}{3\ \mathcal{F}}\right)\left(\frac{69.72\ \text{g}}{\text{mol}}\right)$$

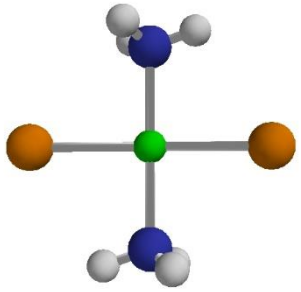
$$= 0.0606\ \text{g}$$

Homework 17.20

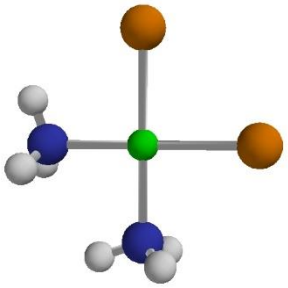
5. Provide three significant ways in which transition metals are different from main group metals. (10 points)

   1) Their compounds tend to be colored, while main group (MG) compounds are generally white.
   2) For any particular metal, they tend to form ions of many oxidation states, while MG metals will form one or two ions.
   3) They tend to form complex ions, while MG metals don't.
   4) Higher oxidation numbers become more stable down a group, while the reverse is true of MG elements.

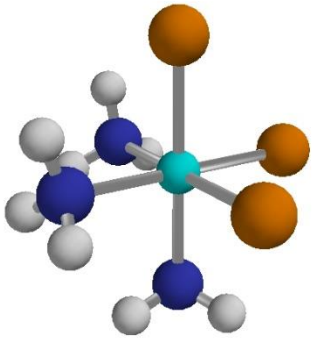
6. Label the following figures by structural isomer type. (12 points)



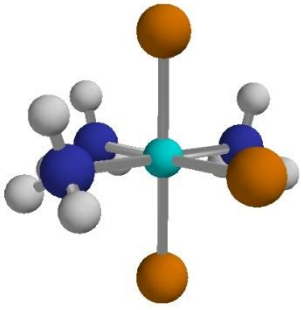
cis



trans



facial



meridonal