INSTRUCTIONS/SUGGESTIONS.
READ THIS CAREFULLY!

EACH QUESTION IS WORTH 10 POINTS.
OMIT ANY FOUR (4) OF THE 18 QUESTIONS.

INDICATE ON THE NEXT PAGE WHICH 4 QUESTIONS ARE NOT TO BE GRADED BY WRITING DNG (DO NOT GRADE) NEXT TO THE PROBLEM NUMBER.

NO PARTIAL CREDIT on any question except where indicated by the statement SHOW WORK. When work is requested, set up equations (with numbers substituted in appropriate units) in space provided, but do the calculations on scrap sheet.

IF QUESTION STATES "SHOW WORK" AND YOU GUESS CORRECTLY WITHOUT SHOWING WORK - YOU GET 1/2 CREDIT.

CHECK FRONT BLACKBOARD FOR CORRECTIONS/CHANGES.

IF ANY QUESTION IS NOT CLEAR - ASK DAVID OR ME ABOUT IT!

CONSTANTS AND CONVERSION FACTORS ARE ON THE PAGE FOLLOWING THE LAST PROBLEM. PLEASE LOOK THERE!
LAST THREE PAGES ARE FOR SCRAP WORK.
FEEL FREE TO TEAR THESE PAGES OFF.

REMOVE THIS PAGE PRIOR TO STARTING EXAM.
CHEMISTRY F14O4              FIRST EXAM           2/16/00
PROFESSOR J. MORROW

PRINT NAME, LAST: ____________________________
FIRST: ________________________________
I.D.#: ________________________________

____________________________________________________

EACH QUESTION IS WORTH 10 POINTS

1. _______      7. _______      13. _______

2. _______      8. _______      14. _______

3. _______      9. _______      15. _______

4. _______      10. _______     16. _______

5. _______     11. _______     17. _______

6. _______     12. _______     18. _______

COLUMN TOTALS:

                     _______                       _______         _______

EXAM TOTAL (14O pts) __________                 __________
OUT OF 100
1) GIVEN THE FOLLOWING STANDARD REDUCTION POTENTIALS (25°C)

\[
\begin{align*}
\text{Ag(CN)}_2^- + e^- &\rightarrow \text{Ag}^0 + 2 \text{CN}^- \quad E^o = -0.310 \text{ V} \\
\text{Ag}^+ + e^- &\rightarrow \text{Ag}^0 \quad E^o = 0.800 \text{ V} \\
\text{Cu}^+ + e^- &\rightarrow \text{Cu}^0 \quad E^o = 0.520 \text{ V} \\
\text{Cu(CN)}_2^- + e^- &\rightarrow \text{Cu}^0 + 2 \text{CN}^- \quad E^o = -0.440 \text{ V}
\end{align*}
\]

Calculate \( \Delta G^o_{\text{rxn}} \) (in kJ) for the following reaction; SHOW WORK

\[
\begin{align*}
\text{Cu(CN)}_2^- + \text{Ag}^+ &\rightarrow \text{Ag(CN)}_2^- + \text{Cu}^+ \\
\end{align*}
\]

\[\text{a)} -14.5 \quad \text{ b)} 12.5 \quad \text{ c)} 14.5 \quad \text{ d)} -12.5 \quad \text{ e)} 25.0 \quad \text{ f)} -25.0\]

ANSWER: \( \Delta G^o_{\text{rxn}} = \)

2) For the reaction, \(2 \text{ Hg(\lambda)} + \text{Cl}_2(g) \rightarrow \text{Hg}_2\text{Cl}_2(S)\), \( E^o = +1.058 \) volts.

For the reaction, \(2 \text{Ag(S)} + \text{Cl}_2(g) \rightarrow 2 \text{AgCl(S)}, \quad E^o = +1.178 \) volts.

Calculate the equilibrium constant for the following reaction;

\[
2 \text{AgCl(S)} + 2 \text{Hg(\lambda)} \rightarrow \text{Hg}_2\text{Cl}_2(S) + 2 \text{Ag(S)}
\]

ANSWER: \( K = \)

3) For the equilibrium reaction, \( \text{Ag}^+ + 2 \text{CN}^- \rightarrow \text{Ag(CN)}_2^- \), the cell notation when the reactants and products are in standard state is;

\[
\text{Ag(S)} \mid \text{Ag(CN)}_2^- (1.00 \text{ M}), \text{CN}^- (1.00 \text{ M}) \parallel \text{Ag}^+(1.00 \text{ M}) \mid \text{Ag(S)}
\]

If the cell with the new indicated concentrations is now set up,

\[
\text{Ag(S)} \mid \text{Ag(CN)}_2^- (2.00 \text{ M}), \text{CN}^- (2.00 \text{ M}) \parallel \text{Ag}^+(0.50 \text{ M}) \mid \text{Ag(S)}
\]

then,

a) The reaction will shift to the right
b) The reaction will shift to the left  
c) The cell voltage will become more positive  
d) The cell voltage will become less positive  
e) The cell voltage will be unchanged  
f) The equilibrium constant will increase in value  
g) The equilibrium constant will decrease in value

YOUR ANSWER(S) IS/ARE: ______

4) Given the reaction,  \( 2 \text{Hg(λ)} + \text{Cl}_2(\text{g}) \longrightarrow \text{Hg}_2\text{Cl}_2(\text{S}) \)

Assume that the standard \( E^\circ \) cell voltage is related to the celcius temperature by the following equation and all substances are at standard state. In doing this, you can assume any temperature(s) you desire.

At 298 K (25°C), \( E^\circ_{\text{cell}} = +1.058 \) volts.  SHOW WORK

\[
E^\circ_{\text{cell}} = 1.058 - 0.00017 (t - 25^\circ C)
\]

The \( \Delta H^\circ \) (in kJ) for the reaction (as written) at 298 K is;

a) -321  
b) +107  
c) +214  
d) -214  
e) -107  
f) +321

ANSWER IS: ______

5) What is the highest pH at which 0.050 M Mn\(^{2+} \) remains entirely in a solution that is saturated with H\(_2\)S, at a concentration of, \([\text{H}_2\text{S}] = 0.10 \) M.

Given: For the reaction, \( \text{MnS(S)} \rightleftharpoons \text{Mn}^{2+} + \text{S}^{2-} \), \( K_{sp} = 3.6 \times 10^{-15} \)  OR
for the reaction, \( \text{MnS(S)} + \text{H}_2\text{O} \rightleftharpoons \text{Mn}^{2+} + \text{HS}^{-} + \text{OH}^{-} \), \( K = 3.0 \times 10^{-14} \)

For H\(_2\)S:  \( K_{a1} = 9.2 \times 10^{-8} \) and \( K_{a2} = 1.2 \times 10^{-15} \) SHOW WORK

a) 2.9  
b) 3.9  
c) 4.4  
d) 4.9  
e) 5.4

ANSWER IS: ______

6) Find among the pH values on the right, the value which most closely matches the pH of the solutions described in the first column. SHOW ALL WORK FOR PART B ON THIS PAGE!

HINT: In PART B the following reaction occurs, \( \text{H}_2\text{CO}_3 + \text{CO}_3^{2-} \longrightarrow \text{2 HCO}_3^- \)
SOLUTION

A. 0.460 M CH₃COOH (HOAc) that is also 0.0460 M in HNO₃

B. 0.020 M H₂CO₃ that is also M in Na₂CO₃

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5.04</td>
</tr>
<tr>
<td>B</td>
<td>11.12</td>
</tr>
</tbody>
</table>

(4 pts) Solution A pH =

(6 pts) Solution B pH =

Kₐ values: H₂CO₃ (Kₐ₁ = 4.3×10⁻⁷), HCO₃⁻ (Kₐ₂ = 4.4×10⁻¹¹), HOAc (Kₐ = 1.8×10⁻⁵)

Solution A:

Solution B:
7) If 0.77 g of Cu(IO₃)₂ will dissolve in 1.0 L of 0.10 M CuSO₄ solution, what is the solubility product, Kₚₛₚ, of Cu(IO₃)₂? Molar mass = 413.3 g/mol

**SHOW WORK**

a) 1.4x10⁻⁵  
b) 1.4x10⁻⁶  
c) 2.6x10⁻⁷  
d) 3.5x10⁻⁷  
e) 2.6x10⁻⁸

**ANSWER IS:** ____

**THE FOLLOWING INFORMATION IS FOR PROBLEMS 8, 9, AND 10.**

40.00 mL of 0.100 M methylamine, CH₃NH₂, is titrated with 0.150 M HCl.

Calculate the pH;  
(Kᵦᵢₐᵦᵦ = 4.0x10⁻⁵ for CH₃NH₂ + H₂O → CH₃NH₃⁺ + OH⁻)

8) before any HCl is added.

**pH = _______**

9) halfway to the equivalence point.

**pH = _______**

10) at the equivalence point. (This is now a hydrolysis problem)

**SHOW WORK**

**pH = _______**

11) How many milliliters (mL) of a 0.0500 M NaOH (a strong base) solution should be added to 1.00 L of 0.100 M H₃PO₄ solution, to produce a buffer of pH = 2.00? For H₃PO₄, Kᵦ₁ = 6.67x10⁻³ (SHOW WORK)
GIVEN: $H_3PO_4 + OH^- \ (\text{from} \ NaOH) \rightarrow H_2PO_4^- + H_2O$

a) 100  	b) 200  	c) 400  	d) 600  
e) 800  
f) 900

ANSWER IS: _______

12) Given the following cell; $Zn(s)|Zn^{2+}(1 \ M) \ || \ H^+(? \ M)|H_2(g)(1 \ atm)$. The measured cell voltage is $E_{cell} = 0.653 \ V$. Calculate the pH of the solution in the cathode compartment. HINT: First calculate $E^0_{cell}$. MOLARITIES AND PRESSURE ARE GIVEN IN THE CELL NOTATION ABOVE.

Given: $Zn^{2+} + 2 e^- \rightarrow Zn(s)$  \quad $E^0 = -0.771 \ V$

a) 1.0  	b) 1.5  	c) 2.0  	d) 3.0  
e) 3.5  
f) 4.0

ANSWER IS: _______

13) Complete the following table. (For $Ca_3(PO_4)_2$, $K_{sp} = 1.3 \times 10^{-32}$)

<table>
<thead>
<tr>
<th>$[Ca^{2+}]$</th>
<th>$[PO_4^{3-}]$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$1.0 \times 10^{-4} \ M$</td>
</tr>
<tr>
<td>$6.0 \times 10^{-3} \ M$</td>
<td></td>
</tr>
</tbody>
</table>

14) You have a solution of sodium hydrogen sulfate, $NaHSO_4$. It's initial concentration is $C_0$. The pH = 2.0 for this solution at equilibrium. Calculate the starting concentration, $C_0$.

(For the reaction, $HSO_4^- \rightarrow H^+ + SO_4^{2-}$, $K_{a2} = 0.020$)

$C_0 = _______

15) For $Ag_2CO_3$, $K_{sp} = 6.2 \times 10^{-12}$. For $AgCl$, $K_{sp} = 2.8 \times 10^{-10}$. Solid $Ag_2CO_3$ and solid $AgCl$ are added to a beaker containing 1.00 M $Na_2CO_3(aq)$. Under these conditions the $[CO_3^{2-}] = 1.00 \ M$. Calculate the $[Cl^-]$ in solution when equilibrium is established.
ASSUME THE CO$_3^{2-}$ ION DOES NOT HYDROLYZE. SHOW WORK

a) $1.1 \times 10^{-4}$  

b) $1.26 \times 10^{-8}$ 

c) 6.7 

d) 0.15 

e) $2.8 \times 10^{-6}$

ANSWER IS: ______

16) Given the following K$_{sp}$ values: for M(OH)$_4$, K$_{sp(M)} = 4.0 \times 10^{-19}$; 

for Z(OH)$_2$, K$_{sp(Z)} = 1.0 \times 10^{-14}$. One mole of each of the above solids is placed in a beaker containing 1 (one) liter of pure water. These solids go into equilibrium with their ions. Calculate the pH required for the metal ion concentrations to be equal, [M$^{2+}$] = [Z$^{3+}$]. (SHOW WORK)

a) 12.6  

b) 9.6 

c) 6.7 

d) 2.2 

e) 11.8

pH = ______

17) Given the following K$_a$ and K$_b$ values: HF (K$_a = 10^{-4}$), HCN (K$_a = 10^{-9}$), 

NH$_3$ (K$_b = 10^{-5}$), HOAc (K$_a = 10^{-5}$), and HCl (K$_a = \infty$)

List the following aqueous salts in order of increasing acidity (decreasing basicity); NaF, NH$_4$Cl, 

NaCN, NaCl, and NaOAc. THIS IS AN HYDROLYSIS PROBLEM.

LEAST ACIDIC _____ < _____ < _____ < _____ < _____ MOST ACIDIC
18) Which graph correctly illustrates the dependence of the cell voltage, $E_{\text{cell}}$, on the pH for the reaction, \[ 2 \text{Ag}^+_{(aq)} + \text{H}_2(g) \rightarrow 2 \text{Ag}(s) + 2 \text{H}^+_{(aq)} \].

Assume the silver ion remains constant at, $[\text{Ag}^+] = 1.0 \text{ M}$ and the H$_2$ pressure remains constant at 1 atm.

Answer is: _ _
1. \( \Delta G^o = -RT \ln K \)

2. \( \frac{(\Delta G^o_2 - \Delta G^o_1)}{\Delta T} = -\Delta S^o \)

3. \( \Delta G^o = -nFE^o \)

4. \( \Delta G^o = \Delta H^o - T\Delta S^o \)

5. \( \Delta S^o = nF\left\{ \frac{E^o_2 - E^o_1}{\Delta T} \right\} \) where \( \Delta T = T_2 - T_1 \)

6. \( \Delta H^o = -nF\left\{ E^o - T\left( \frac{E^o_2 - E^o_1}{\Delta T} \right) \right\} \) where \( \Delta T = T_2 - T_1 \)

7. 1 Faraday = 96500 Coulombs

8. \( E = E^o - \frac{0.0592}{n} \log Q \) (Nernst Equation)
SCRAP WORK SHEET
SCRAP WORK SHEET
SCRAP WORK SHEET