CHEM 103 TEST 2 KEY
Average ± std deviation = 88 (59%) ±27 (18%) Highest score = 147/150 (98%)
Rough corresponding grade: A = 120 and above; B = 105 + , C = 70 +
Part I

1 B 2 E 3 D 4 E	5 A 6 C 7 B	8 C 9 C 10 C

Part II

1)
At T=232K, $\Delta G°=0$: $0=\Delta H°-T\Delta S° \Rightarrow \Delta S° = \Delta H°/T = (2290 J/mol)/(232K) = 9.87$ J/molK

2) ATP hydrolysis is used to drive nonspontaneous reactions. To do this, it is coupled to the reaction with the help of enzymes. Together the reactions have a net $\Delta G < 0$ thus allowing the reaction to occur.

3) $MnO_4^- + MnO_2 <==> MnO_4^{2-}$
+7 +4 +6
(i) $1 e^- + MnO_4^- \to MnO_4^{2-}$ and (ii) $MnO_2 \to MnO_4^{2-} + 2 e$; note that (i) is already balance. (ii) $MnO_2 + 4 OH^- \to MnO_4^{2-} + 2e^- + 2 H_2O$. Add 2x(i) + (ii) :
$2 MnO_4^- + MnO_2 + 4 OH^- \to 3 MnO_4^{2-} + 2 H_2O$

4) Solution: $E_{cell} = E_{red,+} - E_{red,-} = -(0.0592/2)\log(1/2.5) - (-(.0592/2)\log(1/2.5x10^{-6}))$
$= .0296 \log(2.5) – 0.0296 \log(2.5x10^{-6}) = .0296 \log(2/5/2.5x10^{-6}) = .0296(6) = 0.18$ V
5) Solution: we need to reverse (ii) first: $Eu^{2+} + 2e^- \to Eu$ -2.81 V then we can add it to (i) to get the desired half reaction, For, E we need to first all E's as ΔG's, add the ΔG's and then revert back to E: - 0.35 V becomes +0.35 F; - 2.81 V becomes -(2.81)(-2)F = +5.62F . Add them to get $\Delta G_{net} = (0.35+5.62)F=5.98$ F . Convert back to E: E = (5.98F)/(-3F) = **-1.99 V**

6) Solution: $Ag_2C_2O_4 (s) <==> 2 Ag^+ + C_2O_4^{2-}$ $K_{sp} = [Ag^+]^2[C_2O_4^{2-}]$
$= (2(7.0x10^{-5}))^2(7.0x10^{-5}) = 1.37x10^{-12}$

7)
Solution: $Fe(OH)_3 <==> Fe^{3+} + 3 OH^-$ $K_{sp} = 4.0x10^{-38} = [Fe^{3+}][OH^-]^3 =$
= $1.0x10^{-3}$ [OH]
$(1.0x10^{-3})[OH^-]^3 = 4.0x10^{-38} \Rightarrow [OH^-] = 3.4x10^{-12} \Rightarrow pOH = 11.46 \Rightarrow$ **pH = 2.54**

8) solution: $Ca(OH)_2 (s) <==> Ca^{2+} + 2 OH^-$ $K_{sp} = 6.5x10^{-6}$
$Ca^{2+} + Ac^- <==> Ca(Ac)^+$ $K_f = 1.7 x10^1$
Net: $Ca(OH)_2 + Ac^- <==> Ca(Ac)^+ + 2 OH^-$ $K_{net} = 1.1 x 10^{-4}$
1.00 x 2x
$K_{net} = K_{sp}K_f = (6.5x10^{-6})(1.7 x10^1) = 1.1 x 10^{-4} = (x)(2x)^2/1.00 \Rightarrow 4x^3 = 1.1x10^{-4}$
And $x = \sqrt[3]{(1.1x10^{-4}/4)}$ = **0.030 M**

Part III

1) Solution: This is a concentration cell. $E_{cell} = -0.0592/1\ (\log(1/[Ag^+]) - \log(1/x))$
$= -0.0592 \log((1/1.00) / 1/x) = -0.0592\ V \log(x) = 0.230\ V\ = \log x = -3.885$
$x = 10^{-3.885} => x = 1.3 \times 10^{-4}$; and $Ag_3PO_4 <==> 3\ Ag^+ + PO_4^{3-}$
so that $[Ag^+] = 1.3x10^{-4}$; $[PO_4^{3-}] = (1.3x10^{-4})/3 = 4.34x10^{-5}$
and so $K_{sp} = [Ag^+]^3[PO_4^{3-}] = (1.3x10^{-4})^3(4.3x10^{-5}) = \mathbf{9.4 \times 10^{-17}}$

2)
a) solution:
$\Delta G° = 3(-394.359)-2(-742.2) = -1183.077 + 1484.4 = +301.323$ kJ/mol
$= 301.323\ x10^3$ J/mol
$=> K_p = \exp(-\Delta G°/RT) = \exp(-(301.323\ x10^3\ J/mol)((8.314J/molK)(298K)))=\exp(-122)$
$\mathbf{K_p = 1.52x10^{-53}}$

b) (let's solve for the values of $\Delta H°$, $\Delta S°$, and $\Delta G°$)
$\Delta H° = 3(-393.509) – 2(-824.2) = 467.873$ kJ/mol $= 467.873\ x10^3$ J/mol
$\Delta S° = 3(213.74) + 4(27.78) – 2(87.4) -3(5.74) = 641.22+111.12-174.8-17.22=560.32$ J/molK
$T = 547+273 = 820\ K => \Delta G°=\Delta H°-T\Delta S° = 467.873\ x10^3 –(820)(560.32) =>8410.6$ J/mol
$K_p = \exp(-(8410)/((8.314)(820))) = \exp(-3.38) = 0.0336$
But : $K_p = P_{CO2}^3 = x^3 => x = \sqrt[3]{K_p} = \sqrt[3]{(0.0336)} = 0.$**323 bar**

c) Solution: at this T, $\Delta G° = 0 => 0 = \Delta H° - T\Delta S°$
$=> T = \Delta H°/\Delta S° = (467.873\ x10^3\ J/mol)/(560.32\ J/molK) = 835\ K =$ **562 °C**