FORMULA SHEET (tear off)

1A												3A	4A	5A	6A	7A	8A
1 H 1.01	2A																2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.41	31 Ga 69.72	32 Ge 72.64	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc [98]	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	71 Lu 175.0	72 Hf 178.5	73 Ta 181.0	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po [209]	85 At [210]	86 Rn [222]
87 Fr [223]	88 Ra [226]	103 Lr [262]	104 Rf [261]	105 Db [262]	106 Sg [266]												

57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm [145]	62 Sm 150.4	63 Eu 152.0	64 Gd 157.2	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0
89 Ac [227]	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np [237]	94 Pu [244]	95 Am [243]	96 Cm [247]	97 Bk [247]	98 Cf [251]	99 Es [252]	100 Fm [257]	101 Md [258]	102 No [259]

$N_A = 6.022 \times 10^{23}$ | $°C = (5/9)(°F - 32)$ | $°F = (9/5)(°C) + 32$

1 amu = 1.661×10^{-27} kg | $°C = K - 273.15$ | $K = °C + 273.15$

1 atm = 760 torr = 760 mm Hg | 1 atm = 1.013 bar | $pV = nRT$

$R = 0.08206$ L·atm/mol·K | 1 L·atm = 101.3 J

$R = 8.314$ J/mol·K | 1 J= 1 kg·m^2/s^2

$F = 96485.$ C/mol | (1 v) (1 C) = 1 J

$\ln(p) = - \frac{\Delta H°_{vap}}{T} + C$ | $\ln(p_2/p_1) = - (\Delta H°_{vap}/R) \{ (1/T_2) - (1/T_1) \}$

$p_A = X_A p_A°$ | $[B] = k p_B$ | $\Delta p_A = X_B p_A°$

$\Delta T_b = K_b m_B$ | $\Delta T_f = K_f m_B$ | $\Pi = [B]RT$

$H = U + pV$ | $G = H - TS$

$\Delta G_{rxn} = \Delta G°_{rxn} + RT \ln Q$ | $\ln K = - \Delta G°_{rxn}/RT$ | $K_p = K_C (RT)^{\Delta n}$

If $ax^2 + bx + c = 0$, then $x = \frac{- b \pm [b^2 - 4ac]^{1/2}}{2a}$

$K_a \cdot K_b = K_w = 1.0 \times 10^{-14}$ (at T = 25°C)

$\Delta G = - nFE_{cell}$ | $E_{cell} = E°_{cell} - (RT/nF) \ln Q$ | $\ln K = nFE°_{cell}/RT$

GENERAL CHEMISTRY 2
THIRD EXAM (SAMPLE)

Name _____

Panthersoft ID _____

Signature _____

Part 1 _____ **(24 points)**

Part 2 _____ **(30 points)**

Part 3 _____ **(46 points)**

TOTAL_____ **(100 points)**

Do all of the following problems. Show your work.

Part 1. Multiple choice. Circle the letter corresponding to the correct answer. There is one and only one correct answer per problem. [4 points each]

1) Which of the following reactions goes essentially to completion in aqueous solution?

a) The reaction of a strong acid with a strong base
b) The reaction of a strong acid with a weak base
E c) The reaction of a weak acid with a strong base
d) Both a and b
e) Both a and b and c

2) A small amount of a strong base is added to a buffer solution. The pH of the buffer solution

a) will increase significantly
b) will increase by a small amount
B c) will be unchanged
d) will decrease by a small amount
e) will decrease significantly

3) 0.010 moles of $HClO_2$ (chlorous acid, a weak monoprotic acid) is added to 1.000 L of each of the following solutions. For which solution will the percent ionization of the chlorous acid be largest?

a) A 1.0×10^{-3} M solution of HNO_2 (nitrous acid, a weak acid)
b) A 1.0×10^{-3} M solution of HBr (hydrobromic acid, a strong acid)
D c) A 1.0×10^{-3} M solution of NH_3 (ammonia, a weak base)
d) A 1.0×10^{-3} M solution of KOH (potassium hydroxide, a strong base)
e) Pure water

4) Which of the following indicators would be the best to use in the titration of a strong acid by a strong base?

a) alizarin yellow ($pK_{ind} = 11.0$)
b) bromothymol blue ($pK_{ind} = 6.8$)
B c) bromophenol blue ($pK_{ind} = 3.8$)
d) thymol blue ($pK_{ind} = 2.0$)
e) All of the above would be suitable indicators for the titration

5) For a galvanic cell reaction to be spontaneous for standard conditions which of the following must be true?

a) $\Delta G°_{rxn} > 0$ and $E°_{cell} > 0$
b) $\Delta G°_{rxn} > 0$ and $E°_{cell} < 0$
C c) $\Delta G°_{rxn} < 0$ and $E°_{cell} > 0$
d) $\Delta G°_{rxn} < 0$ and $E°_{cell} < 0$
e) both c and d

6) The standard reduction potential for the process

$$Cu^{2+}(aq) + 2\ e^- \rightarrow Cu(s)$$

is $E° = +\ 0.34$ v. Based on this, we can say that the half-cell oxidation potential for the process

$$2\ Cu(s) \rightarrow 2\ Cu^{2+}(aq) + 4\ e^-$$

is

a) $E° = +\ 0.68$ v
b) $E° = +\ 0.34$ v
D c) $E° = \ \ 0.00$ v
d) $E° = -\ 0.34$ v
e) $E° = -\ 0.68$ v

Part 2. Short answer.

1) What is the pH of a saturated aqueous solution of manganese (II) hydroxide ($Mn(OH)_2$), at T = 25. °C. The value for the solubility product of manganese (II) hydroxide at this temperature is $K_{sp} = 2.1 \times 10^{-13}$. [10 points]

$Mn(OH)_2(s) \leftrightarrows Mn^{2+}(aq) + 2\ OH^-(aq)$ $\quad Ksp = [Mn^{2+}]\ [OH^-]^2 = 2.1 \times 10^{-13}$

	Initial	Change	Equilibrium	
Mn^{2+}	0	x	x	$(x)(2x)^2 = 4x^3 = 2.1 \times 10^{-13}$
OH^-	0	2x	2x	
				$x^3 = (2.1 \times 10^{-13})/4 = 5.25 \times 10^{-14}$
				$x = (5.25 \times 10^{-14})^{1/3} = 3.74 \times 10^{-5}$

$[OH^-] = 2x = 2(3.74 \times 10^{-5}) = 7.49 \times 10^{-5}$

$pOH = -\log_{10}(7.49 \times 10^{-5}) = 4.13$ $\quad pH = 14.00 - pOH = 14.00 - 4.13 = 9.87$

2) What is the oxidation number for phosphorus (P) in each of the following molecules? [3 points each]

Na_3P _____-3_____ $\quad PH_3$ _____-3_____

P_4 _____0_____ $\quad P_2O_5$ _____+5_____

3) Calcium metal can be obtained from the electrolysis of a molten solution of calcium chloride ($CaCl_2$). How many grams of calcium metal can be produced when a sample of molten $CaCl_2$ undergoes electrolysis for 4.00 hours using a current i = 25.0 amps (1 amp = 1 C/s)? [8 points]

Production of calcium metal is by the process $Ca^{2+} + 2\ e^- \rightarrow Ca$

$$\text{grams calcium} = 4.00 \text{ hours} \frac{3600 \text{ s}}{1 \text{ hr}} \frac{25.0 \text{ C}}{1 \text{ s}} \frac{1 \text{ mol } e^-}{96485 \text{ C } e^-} \frac{1 \text{ mol Ca}}{2 \text{ mol } e^-} \frac{40.08 \text{ g Ca}}{1 \text{ mol Ca}} = 74.8 \text{ g Ca}$$

Part 3. Problems.

1) Consider the following solution, which contains initial amounts of both HCl and NH_3.

a) Find the pH of the a solution initially containing 0.0100 M hydrochloric acid (HCl), a strong acid, and 0.0100 M ammonia (NH_3), a weak base, with $K_b = 1.8 \times 10^{-5}$. Assume T = 25. °C. [12 points]

$HCl(aq) + NH_3(aq) \rightarrow NH_4^+(aq) + Cl^-(aq)$ Since we have equal concentrations of HCl and NH_3, the Reaction goes to completion.

$NH_4^+(aq) + H_2O(\ell) \leftrightarrows H_3O^+(aq) + NH_3(aq)$ $K_a = (1.0 \times 10^{-14})/K_b =$

$(1.0 \times 10^{-14})/(1.8 \times 10^{-5}) = 5.56 \times 10^{-10}$

$K_a = \dfrac{[H_3O^+]\,[NH_3]}{[NH_4^+]} = 5.56 \times 10^{-10}$

$\dfrac{(x)\,(x)}{(0.0100 - x)} = 5.56 \times 10^{-10}$ Assume $x << 0.010$

	Initial	Change	Equilibrium
NH_4^+	0.0100	-x	0.0100 - x
NH_3	0	x	x
H_3O^+	0	x	x

$\dfrac{x^2}{(0.0100)} = 5.56 \times 10\text{-}10$ $x^2 = (0.0100)\,(5.56 \times 10^{-10}) = 5.56 \times 10^{-12}$

$x = (5.56 \times 10^{-12})^{1/2} = 2.36 \times 10^{-6}$ (so x is small)

$[H_3O^+] = 2.36 \times 10^{-6}$ $pH = -\log_{10}[H_3O^+] = -\log_{10}(2.36 \times 10^{-6}) = 5.63$

b) Is the above solution a buffer solution (yes/no and a brief justification of your answer)? [4 points]

No. After the reaction takes place there is a weak conjugate acid present (NH_4^+), but there is no significant concentration of weak base ($[NH_3] = 2.4 \times 10^{-6}$).

2) Balance the following unbalanced oxidation-reduction reaction [10 points each]

$SO_2(g) + Fe^{3+}(aq) \rightarrow SO_4^{2-}(aq) + Fe^{2+}(aq)$ (for acid conditions)

ox $SO_2(g) + 2\,H_2O(\ell) \rightarrow SO_4^{2-}(aq) + 4\,H^+(aq) + 2\,e^-$

red $Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$ x 2

net $SO_2(g) + 2\,Fe^{3+}(aq) + 2\,H_2O(\ell) \rightarrow SO_4^{2-}(aq) + 2\,Fe^{2+}(aq) + 4\,H^+(aq)$

3) A portion of the electrochemical series is given below and may be of use in doing the following problem.

$2\ H^+(aq) + 2\ e^- \rightarrow H_2(g)$ $E° = 0.00$ v	$Co^{2+}(aq) + 2\ e^- \rightarrow Co(s)$ $E° = -0.28$ v
$Pb^{2+}(aq) + 2\ e^- \rightarrow Pb(s)$ $E° = -0.13$ v	$Cd^{2+}(aq) + 2\ e^- \rightarrow Cd(s)$ $E° = -0.40$ v
$Sn^{2+}(aq) + 2\ e^- \rightarrow Sn(s)$ $E° = -0.14$ v	$Cr^{3+}(aq) + 3\ e^- \rightarrow Cr(s)$ $E° = -0.74$ v
$Ni^{2+}(aq) + 2\ e^- \rightarrow Ni(s)$ $E° = -0.25$ v	$Mn^{2+}(aq) + 2\ e^- \rightarrow Mn(s)$ $E° = -1.18$ v

Give the half cell oxidation reaction, the half cell reduction reaction, the net cell reaction, and the value for $E°_{cell}$ and E_{cell} for the galvanic cell whose cell diagram is given below. [20 points]

$Cr(s) \mid Cr^{3+}(4.5 \times 10^{-2}\ mol/L) \parallel Sn^{2+}(6.0 \times 10^{-4}\ M) \mid Sn(s)$

ox	$Cr(s) \rightarrow Cr^{3+}(aq) + 3\ e^-$	x 2	$E° = +0.74$ v
red	$Sn^{2+}(aq) + 2\ e^- \rightarrow Sn(s)$	x 3	$E° = -0.14$ v
net	$2\ Cr(s) + 3\ Sn^{2+}(aq) \rightarrow 2\ Cr^{3+}(aq) + 3\ Sn(s)$		$E°_{net} = +0.60$ v

From Nernst,

$$E_{cell} = E°_{cell} - (RT/nF) \ln Q$$

$$Q = \frac{[Cr^{3+}]^2}{[Sn^{2+}]^3} = \frac{(4.5 \times 10^{-2})^2}{(6.0 \times 10^{-4})^3} = 9.4 \times 10^6$$

So
$$E_{cell} = 0.60\ v - \frac{8.314\ J/mol{\cdot}K\ (298.\ K)}{(6)\ (96485.\ C/mol)} \ln(9.4 \times 10^6)$$

$$= 0.60\ v - 0.07\ v = 0.53\ v$$