FORMULA SHEET (tear off)

1A	2A											3A	4A	5A	6A	7A	8A
1 H 1.01																	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]

$N_A = 6.022 \times 10^{23}$

$1 \text{ amu} = 1.661 \times 10^{-27}$ kg

1 atm = 760 torr = 760 mm Hg

R = 0.08206 L•atm/mol•K

R = 8.314 J/mol•K

°C = ($^5/_9$) (°F - 32)

°C = K - 273.15

1 atm = 1.013 bar

1 L•atm = 101.3 J

1 J= 1 kg•m^2/s^2

°F = ($^9/_5$)(°C) + 32

K = °C + 273.15

pV = nRT

$p_A = X_A \, p_A°$

$[B] = k \, p_B$

$\Delta p_A = X_B p_A°$

$\Delta T_b = K_b \, m_B$

$\Delta T_f = K_f \, m_B$

$\Pi = [B]RT$

$H = U + pV$

$G = H - TS$

$\Delta G_{rxn} = \Delta G°_{rxn} + RT \ln Q$

$\ln K = - \Delta G°_{rxn}/RT$

$K_p = K_C (RT)^{\Delta n}$

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

GENERAL CHEMISTRY 2
SECOND EXAM

Name ____

Panthersoft ID ____

Signature ____

Part 1 ______________ **(16 points)**

Part 2 ______________ **(38 points)**

Part 3 ______________ **(26 points)**

TOTAL ______________ **(80 points)**

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Do all of the following problems. <u>Show your work.</u>

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) The numerical value for the equilibrium constant for the reaction $A_2(g) + 2\ B(g) \leftrightarrows 2\ AB(g)$ is $K_C = 25.$ The numerical value for the equilibrium constant for the reaction $AB(g) \leftrightarrows \frac{1}{2}\ A_2(g) + B(g)$, measured at the same temperature, is

a) $K_C = 0.040$
b) $K_C = 0.20$
B c) $K_C = 5.0$
d) $K_C = 25.$
e) Cannot tell from the information given

2) Consider the following chemical reaction.

$$PCl_5(g) \leftrightarrows PCl_3(g) + Cl_2(g)$$

A system containing PCl_3, PCl_5, and Cl_2 at a fixed temperature is initially at equilibrium. Which of the following changes will lead to an increase in the number of moles of PCl_3 in the system?

a) Addition of 0.100 moles of Cl_2 into the system
b) Addition of 0.100 moles of PCl_5 into the system
B c) Decreasing the volume of the system by 2.00 L
d) Both a and c
e) Both b and c

3) A Bronsted base is

a) a proton acceptor
b) a proton donor
A c) an electron pair acceptor
d) an electron pair donor
e) any ionic compound that will dissolve in water

4) Which of the following is a polyprotic acid?

a) $HClO_2$
b) $HClO_3$
E c) HI
d) HNO_3
e) H_2SO_3

Part 2. Short answer.

1) The free energy change for the reaction

$$2\ NO_2(g) \leftrightarrows N_2O_4(g)$$

is $\Delta G°_{rxn} = -\ 5.3$ kJ/mol at T = 25. °C. Based on this information, find the numerical value for K, the equilibrium constant, for this reaction. [6 points]

$$\ln K = -\frac{\Delta G°_{rxn}}{RT} = -\frac{(-\ 5300.\ J/mol)}{(8.314\ J/mol\bullet K)\ (298.\ K)} = 2.14$$

$$K = e^{2.14} = 8.5$$

2) A system containing the gases Cl_2, NO, and NOCl will achieve equilibrium. The process that takes place is

$$2\ NOCl(g) \leftrightarrows 2\ NO(g) + Cl_2(g)$$

At T = 500. K, the partial pressures of gas present at equilibrium are $p(Cl_2)$ = 0.608 atm, p(NO) = 0.240 atm, and p(NOCl) = 1.36 atm.

a) What is the numerical value for K_p for the above reaction at T = 500. K? [4 points]

$$K_p = \frac{[p(NO)]^2\ p(Cl_2)}{[p(NOCl)]^2} = \frac{(0.240)^2\ (0.608)}{(1.36)^2} = 0.0189$$

b) What is the numerical value for K_C for the above reaction at T = 500. K? [4 points]

$K_p = K_C\ (RT)^{\Delta n}$ $\qquad\qquad$ $\Delta n = 3 - 2 = 1$

$$K_C = \frac{K_p}{(RT)^{\Delta n}} = \frac{0.0189}{[(0.08206)(500.)]} = 4.6 \times 10^{-4}$$

(Note we do not include units for R or T because equilibrium constants do not have units).

3) The pH of an aqueous solution is pH = 8.82 at T = 25 °C. Find $[H_3O^+]$, $[OH^-]$, and the pOH for the solution. [8 points total]

pOH = 14.00 - pH = 5.18

$[H_3O^+] = 10^{-pH} = 10^{-8.82} = 1.5 \times 10^{-9}$ M

$[OH^-] = 10^{-pOH} = 10^{-5.18} = 6.6 \times 10^{-6}$ M

4) Answer each of the following questions by filling in the blank. [4 points each]

a) The <u>conjugate base</u> of HCO_3^-. $\qquad$ _____CO_3^{2-}__________

b) The pH of pure water at T = 50.°C. $\qquad$ _____6.63___________
(Note $K_w = 5.5 \times 10^{-14}$ at T = 50.°C)

5) For each of the following questions circle the correct answer. There is one and only one correct answer per question. [4 points each]

A weak acid

HI	HBr	HCl	**HF**

A strong soluble base

AgOH	$Cu(OH)_2$	**$Ba(OH)_2$**	$Fe(OH)_3$

Part 3. Problems.

1) A solution is prepared (at T = 25.0 °C) by adding 2.97 g of potassium hydroxide (KOH, MW = 56.11 g/mol) to water. The final volume of the solution is V = 250.0 mL. What is the pH of the solution? [10 points]

$$\text{moles KOH} = 2.97 \text{ g KOH} \; \frac{1 \text{ mol}}{56.11 \text{ g}} = 0.05293 \text{ mol KOH}$$

The concentration of KOH in the solution is therefore

$$[KOH] = \frac{0.05293 \text{ mol}}{0.2500 \text{ L}} = 0.2117 \text{ mol/L}$$

The reaction for KOH in water is $KOH(s) \rightarrow K^+(aq) + OH^-(aq)$

and so $[OH^-] = [KOH]$

So $pOH = - \log_{10}(0.2117) = 0.67$

$pH = 14.00 – pOH = 14.00 – 0.67 = 13.33$

2) The numerical value for the equilibrium constant for the reaction

$$H_2(g) + I_2(g) \leftrightarrows 2\ HI(g)$$

is K_C = 57.0 at T = 700. K.

The initial concentration of H_2 and I_2 in a system at T = 700. K are $[H_2]$ = 0.2000 mol/L and $[I_2]$ = 0.1000 mol/L. No HI is initially present in the system. What are the concentrations of H_2, I_2, and HI that are present when the system reaches equilibrium? [16 points]

	Initial	Change	Equilibrium
H_2	0.200 0	- x	0.2000 - x
I_2	0.1000	- x	0.1000 - x
HI	0.0000	2x	2x

$$K_C = \frac{[HI]^2}{[H_2]\,[I_2]} = 57.0 = \frac{(2x)^2}{(0.2000 - x)(0.1000 - x)} = \frac{4x^2}{x^2 - 0.300\,x + 0.0200}$$

$$57.0\,x^2 - 17.1\,x + 1.140 = 4x^2$$

$$53.0\,x^2 - 17.1\,x + 1.140 = 0$$

Using the quadratic equation, we get

$$x = \frac{17.1 \pm [\,(17.1)^2 - 4\,(53.0)\,(1.140)\,]^{1/2}}{2\,(53.0)} = \frac{17.1 \pm 7.12}{106.0} = 0.2285,\ \underline{0.09412}$$

The underlined root is correct (the other root would give negative concentrations for H_2 and I_2) and so

$[H_2]$ = 0.200 - 0.09412 = 0.1059 mol/L
$[I_2]$ = 0.100 - 0.09412 = 0.0059 mol/L
[HI] = 2(0.09412) = 0.1882 mol/L

As a check, if we insert these values into the expression for K_C, we get

$$K_C = \frac{(0.1882)^2}{(0.1059)(0.0059)} = 56.7$$, the value initially given (to within roundoff error)

Note that if we do the calculation by assuming that x << 0.1000, we do not get the correct value for x. This means that the assumption that x << 0.1000 is not correct in this problem.