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 amu = 1.661×10^{-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

$p_A = X_A\, p_A°$

$\Delta T_b = K_b\, m_B$

[B] = k p_B

$\Delta T_f = K_f\, m_B$

$\Delta p_A = X_B p_A°$

$\Pi = [B]RT$

H = U + pV

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

G = H - TS

$\ln K = -\Delta G°_{rxn}/RT$

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

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 ________________ **(20 points)**

Part 2 ________________ **(30 points)**

Part 3 ________________ **(30 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) Which of the following general classes of substances does not appear in the expression for the equilibrium constant for a reaction?

a) pure solids
b) solvents
D c) solutes
d) both a and b
e) both b and c

2) For the chemical reaction

$$Cl_2(g) + 2\ NO_2(g) \leftrightarrows 2\ NO_2Cl(g)$$

$K_C = 1.8$ at a temperature T. For a particular set of starting conditions and the same temperature $Q_C = 0.040$ As the system approaches equilibrium, which of the following will occur?

a) The moles of $NO_2Cl(g)$ will increase
b) The moles of $Cl_2(g)$ will increase
A c) The moles of $NO_2(g)$ will increase
d) Both b and c
e) None of the above

3) Consider the following three reactions

I	$H_2(g) + Cl_2(g) \leftrightarrows 2\ HCl(g)$
II	$3\ Fe(s) + 4\ H_2O(g) \leftrightarrows Fe_3O_4(s) + 4\ H_2(g)$
III	$C(s) + H_2O(g) \leftrightarrows CO(g) + H_2(g)$

For which of the above reactions will the numerical value for K_C and K_p be equal?

a) Reaction I only.
b) Reaction II only.
D c) Reaction III only.
d) Both reaction I and reaction II
e) Both reaction I and reaction III

4) Which of the following hydroxide compounds is a strong soluble base?

a) KOH (potassium hydroxide)
b) AgOH (silver hydroxide)
A c) $Ni(OH)_2$ (nickel II hydroxide)
d) Both a and b
e) Both a and b and c

5) The conjugate base of the HSO_4^- anion (hydrogen sulfate anion) is

a) H_2SO_4
b) HSO_4^-
C c) SO_4^{2-}
d) H_3O^+
e) OH^-

Part 2. Short answer.

1) Give the expression for K_C for the following chemical reaction [4 points]

$Pb^{2+}(aq) + 2\ Br^-(aq) \leftrightarrows PbBr_2(s)$

$$K_C = \frac{1}{[Pb^{2+}]\,[Br^-]^2}$$

2) Consider the following chemical reaction

$CO(g) + H_2(g) \leftrightarrows H_2CO(g)$ $\Delta H°_{rxn} = +\ 30.4$ kJ/mol

A system at constant volume containing CO, H_2, and H_2CO is initially at equilibrium. For each of the following changes to the system indicate whether the number of moles of H_2CO in the system will increase, remain the same, or decrease as the system returns to equilibrium. Circle your answer. [4 points each]

a) 0.0200 moles of CO(g) is added to the system

<u>moles of H_2CO increases</u>	moles of H_2CO remains the same	moles of H_2CO decreases

b) The temperature of the system is increased by 20.0 °C

<u>moles of H_2CO increases</u>	moles of H_2CO remains the same	moles of H_2CO decreases

3) An aqueous solution of a weak acid has pH = 5.18 at T = 25. °C. What are the values for pOH and $[H_3O^+]$ for the solution? [4 points each]

pOH = _________8.82_______________ $[H_3O^+]$ = ______6.6×10^{-6} M______________

4) A solution is prepared by dissolving 18.45 g of potassium hydroxide (KOH, M = 56.11 g/mol), a strong soluble base, in water. The temperature of the solution is T = 25.0 °C, and the final volume of the solution is V = 400.0 mL. What is the pH of the solution? [6 points]

$$\text{mol KOH} = 18.45\text{ g}\ \frac{1\text{ mol}}{56.11\text{ g}} = 0.3288\text{ mol}$$

$$[KOH] = \frac{0.3288\text{ mol}}{0.4000\text{ L}} = 0.822\text{ mol/L}$$

But $[KOH] = [OH^-]$, so $[OH^-] = 0.822$ mol/L pOH = - $\log_{10}(0.822) = 0.085$ pH = 14.00 - pOH

= 14.00 – 0.085 = 13.91

5) Hypochlorous acid (HOCl) is a weak acid often used as a disinfectant. Give the correctly balanced reaction corresponding to the addition of HOCl to water in the Bronsted picture of acids and bases. [4 points]

$HOCl(aq) + H_2O(\ell) \leftrightarrows H_3O^+(aq) + OCl^-(aq)$

Part 3. Problems.

1) Using the information given below find the numerical values for $\Delta G°_{rxn}$ and K for the following reaction. You may assume that T = 25. °C. [15 points]

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

Substance	$\Delta H°_f$ (kJ/mol)	$\Delta G°_f$ (kJ/mol)	S° (J/mol•K)
$H_2(g)$	0.00	0.00	130.68
HI(g)	26.48	1.70	206.59
$I_2(g)$	62.44	19.33	260.69

$$\Delta G°_{rxn} = [2\ \Delta G°_f(HI(g))\ ] - [\ \Delta G°_f(H_2(g)) + \Delta G°_f(I_2(g))\ ]$$

$$= [\ 2\ (1.70)\ ] - [\ 0.00 + 19.33\ ] = -\ 15.93\ \text{kJ/mol}$$

$$\ln K = -\frac{\Delta G°_{rxn}}{RT} = -\frac{(-\ 15.93\ \text{kJ/mol})\ (1000\ \text{J/1 kJ})}{(8.314\ \text{J/mol•K})(298.\ \text{K})} = 6.43$$

$K = e^{6.43} = 620.$

2) Because the F-F single bond in F_2 is a weak bond, diatomic fluorine will dissociate at high temperatures. The reaction may be written as

$$F_2(g) \leftrightarrows 2\,F(g) \qquad K_C = 0.064 \text{ at } T = 1500.\text{ K}$$

A closed system at T = 1500. K initially has $[F_2]$ = 0.1400 mol/L. No fluorine atoms are initially present in the system. What will be the value for [F], the concentration of fluorine atoms in the system, when equilibrium is reached? [15 points]

$$K_C = \frac{[F]^2}{[F_2]} = 0.064$$

	Initial	Change	Equilibrium
F	0	2x	2x
F_2	0.1400	- x	0.1400 - x

So $$\frac{(2x)^2}{(0.1400 - x)} = 0.064$$

If we assume x << 0.1400, then

$$\frac{4x^2}{0.1400} = 0.064 \qquad x^2 = \frac{(0.064)\,(.1400)}{4} = 2.24 \times 10^{-3} \qquad x = (2.24 \times 10^{-3})^{1/2} = 0.047$$

But 0.047 is not small compared to 0.1400 (it is not at least 10 times smaller), so we will have to use another method to find x

$$\frac{(2x)^2}{(0.1400 - x)} = 0.064 \qquad 4x^2 = (0.064)\,(0.1400 - x) = 0.00896 - 0.064\,x$$

$$4x^2 + 0.064\,x - 0.00896 = 0$$

So $$x = \frac{-\,0.064 \pm [\,(0.064)^2 - 4\,(4)\,(-\,0.00896)\,]^{1/2}}{2\,(4)} = -\,0.056\,,\ \underline{+\,0.040}$$

The underlined root gives positive concentrations for F_2 and F.

Therefore $[F] = 2x = 2\,(0.040) = 0.080$ M