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]

$N_A = 6.022 \times 10^{23}$ $\quad °C = (^5/_9)\,(°F - 32)$ $\quad °F = (^9/_5)(°C) + 32$

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

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

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

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

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

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

$H = U + pV$ $\quad G = H - TS$

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

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

GENERAL CHEMISTRY 2
SECOND HOUR EXAM
OCTOBER 10, 2018

Name _____**Version 2**_____

Panthersoft ID _____

Signature _____

Part 1 _____ **(20 points)**

Part 2 _____ **(28 points)**

Part 3 _____ **(32 points)**

TOTAL_____ **(80 points)**

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 a chemical reaction depends on

a) pressure
b) volume
C c) temperature
d) Both a and b
e) Both a and b and c

2) Which of the following appear in the expression for the equilibrium constant for a chemical reaction

a) gases
b) solvents
D c) solutes
d) Both a and c
e) Both b and c

3) For the reaction $HCl(aq) + HSO_3^-(aq) \rightarrow H_2SO_3(aq) + Cl^-(aq)$, which substance acts as a Bronsted base?

a) HCl
b) HSO_3^-
B c) H_2SO_3
d) Cl^-
e) Both HSO_3^- and H_2SO_3

4) For an acidic aqueous solution at T = 25.0 °C which of the following will be true?

a) pH > 7.0
b) $[H_3O^+] > 1.0 \times 10^{-7}$ M
B c) $[OH^-] > 1.0 \times 10^{-7}$ M
d) Both a and b
e) Both a and c

5) Which of the following is <u>not</u> a strong acid?

a) HBr
b) $HClO_4$
C c) HNO_2
d) H_2SO_4
e) All of the above substances are strong acids

Version 1: A, E, B, C, D Version 3: A, D, C, A, B Version 4: B, E, A, A, C

Part 2. Short answer.

1) What is the difference (if any) between the reaction quotient Q_C and the equilibrium constant K_C for a chemical reaction? [5 points]

Both the reaction quotient and the equilibium constant are given by the concentration of products over the concentration of the reactants (raised to the appropriate powers). The difference between them is that the equilibrium constant requires the system be at equilibrium, while the reaction quotient can be calculated for any conditions.

2) For the chemical reaction

$$Fe_2O_3(s) + 3\ H_2(g) \leftrightarrows 2\ Fe(s) + 3\ H_2O(g)$$

$K_C = 8.1$ at T = 1000. K.

Consider a system containing all of the reactants and products in a closed container at a constant temperature T = 1000. K. Indicate (by circling the correct answer) whether each of the following changes will lead to an increase in the moles of H_2O, no change in the moles of H_2O, or a decrease in the moles of H_2O as the system re-establishes equilibrium. [3 points each]

Addition of 0.100 moles of $H_2(g)$ to the system

moles of H_2O will increase | moles of H_2O will not change | moles of H_2O will decrease

Increasing the volume of the system by 10.00 L

moles of H_2O will increase | **moles of H_2O will not change** | moles of H_2O will decrease

3) An aqueous solution of an unknown weak acid has pH = 4.37 at T = 25.0 °C. Find pOH, $[H_3O^+]$ and $[OH^-]$ for the solution. [3 points each]

pOH = _____9.63_____ $[H_3O^+]$ = ___4.3 x 10^{-5} M_____ $[OH^-]$ = ___2.3 x 10^{-10} M_____

Version 1: 9.17, 1.5 x 10^{-5} M, 6.8 x 10^{-10} M
Version 3: 9.88, 7.6 x 10^{-5} M, 1.3 x 10^{-10} M
Version 4: 9.45, 2.8 x 10^{-5} M, 3.6 x 10^{-10} M

4) An aqueous solution is prepared by dissolving 0.183 g of rubidium hydroxide (RbOH, MW = 102.5 g/mol) in water, at T = 25.0 °C. The final volume of the solution is V = 500.0 mL. What is the pH of the solution. [8 points]

$$\text{moles RbOH} = 0.183\ \text{g} \times \frac{1\ \text{mol}}{102.5\ \text{g}} = 1.79 \times 10^{-3}\ \text{mol}$$

Since the reaction is $RbOH(s) \rightarrow Rb^+(aq) + OH^-(aq)$

$$\text{moles } OH^- = 1.79 \times 10^{-3}\ \text{mol RbOH} \times \frac{1\ \text{mol } OH^-}{1\ \text{mol RbOH}} = 1.79 \times 10^{-3}\ \text{mol } OH^-$$

$$[OH^-] = \frac{1.79 \times 10^{-3}\ \text{mol } OH^-}{0.5000\ \text{L soln}} = 3.57 \times 10^{-3}\ \text{M}$$

$pOH = -\log_{10}(3.57 \times 10^{-3}) = 2.45$ pH =14.00 - 2.45 = 11.55

Version 1: pH = 11.51 Version 3: pH = 11.65 Version 4: pH = 11.61

Part 3. Problems.

1) Bromine and chlorine gas will establish an equilibrium with the mixed halogen compound bromide monochloride (BrCl). The reaction can be written as

$Br_2(g) + Cl_2(g) \leftrightarrows 2\ BrCl(g)$ $\qquad K_C = 6.2$ at T = 140.0 °C

A system at constant temperature T = 140.0 °C initially has $[Br_2] = 0.0400$ M and $[Cl_2] = 0.120$ M. There is initially no BrCl(g) in the system. Find the concentration of BrCl(g) that is present when the system reaches equilibrium. [14 points]

$$K_C = \frac{[BrCl]^2}{[Br_2]\,[Cl_2]} = 6.2$$

	Initial	Change	Equilibrium
Br_2	0.0400	- x	0.0400 - x
Cl_2	0.120	- x	0.120 - x
BrCl	0	2x	2x

$$\frac{(2x)^2}{(0.0400 - x)\,(0.1200 - x)} = 6.2$$

$4x^2 = 6.2\ (0.0400 - x)\ (0.120 - x) = 6.2\ x^2 - 0.992\ x + 0.02976$

$2.2x^2 - 0.992x + 0.02976 = 0$ $\qquad x = \frac{0.992 \pm [\,(-0.992)^2 - 4\ (4.2)\ (0.02976)\,]^{1/2}}{2\ (2.2)}$

$= 0.419,\ \underline{0.0323}$

The underlined root is the only one that gives only positive final concentrations.

So $[BrCl] = 2x = 2\ (0.0323) = 0.0646$ M

Version 1: 0.0682 M Version 3: 0.0876 M Version 4: 0.0945 M

2) Consider the following gas phase equilibrium between the hydrocarbons propene (C_3H_6), ethene (C_2H_4), and 1-butene (C_4H_8).

$$2\ C_3H_6(g) \leftrightarrows C_2H_4(g) + C_4H_8(g)$$

Thermochemical data for the hydrocarbons appearing in the above reaction are given below (at T = 25.0 °C).

substance	$\Delta H°_f$ (kJ/mol)	$\Delta G°_f$ (kJ/mol)	S° (J/mol·K)
$C_2H_4(g)$	52.26	68.15	219.56
$C_3H_6(g)$	20.42	62.78	267.05
$C_4H_8(g)$ (1-butene)	- 0.13	71.39	305.71

a) Give the expression for K (the thermodynamic equilibrium constant) for the above reaction. [4 points]

$$K = \frac{(p_{C2H4})\,(p_{C4H8})}{(p_{C3H6})^2}$$

b) What is the value for $\Delta G°_{rxn}$ for the above reaction at T = 25.0 °C? [7 points]

$\Delta G°_{rxn}$ = [$\Delta G°f(C_2H_4(g))$ + $\Delta G°_f(C_4H_8(g))$] - [2 $\Delta G°_f(C_3H_6)g)$]

= [(68.15) + (71.39)] - [2 (62.78] = + 13.98 kJ/mol

c) What is the numerical value for K for the above reaction at T = 25.0 °C? [7 points]

$$\ln K = -\frac{\Delta G°_{rxn}}{RT} = -\frac{(13980.\ J/mol)}{(8.314\ J/mol·K)\ (298.\ K)} = -5.64$$

And so $K = e^{-5.64} = 3.5 \times 10^{-3}$