

**FORMULA SHEET (tear off)**

1A										8A																																			
1 H 1.01	2A										3A	4A	5A	6A	7A	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]																																								
<table border="1"> <tr> <td>57 La 138.9</td> <td>58 Ce 140.1</td> <td>59 Pr 140.9</td> <td>60 Nd 144.2</td> <td>61 Pm [145]</td> <td>62 Sm 150.4</td> <td>63 Eu 152.0</td> <td>64 Gd 157.2</td> <td>65 Tb 158.9</td> <td>66 Dy 162.5</td> <td>67 Ho 164.9</td> <td>68 Er 167.3</td> <td>69 Tm 168.9</td> <td>70 Yb 173.0</td> </tr> <tr> <td>89 Ac [227]</td> <td>90 Th 232.0</td> <td>91 Pa 231.0</td> <td>92 U 238.0</td> <td>93 Np [237]</td> <td>94 Pu [244]</td> <td>95 Am [243]</td> <td>96 Cm [247]</td> <td>97 Bk [247]</td> <td>98 Cf [251]</td> <td>99 Es [252]</td> <td>100 Fm [257]</td> <td>101 Md [258]</td> <td>102 No [259]</td> </tr> </table>																		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]
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$$N_A = 6.022 \times 10^{23}$$

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

$$1 \text{ atm} = 760 \text{ torr} = 760 \text{ mm Hg}$$

$$R = 0.08206 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K}$$

$$R = 8.314 \text{ J}/\text{mol}\cdot\text{K}$$

$$^\circ\text{C} = (5/9)(^\circ\text{F} - 32)$$

$$^\circ\text{C} = \text{K} - 273.15$$

$$1 \text{ atm} = 1.013 \text{ bar}$$

$$1 \text{ L}\cdot\text{atm} = 101.3 \text{ J}$$

$$1 \text{ J} = 1 \text{ kg}\cdot\text{m}^2/\text{s}^2$$

$$^\circ\text{F} = (9/5)(^\circ\text{C}) + 32$$

$$\text{K} = ^\circ\text{C} + 273.15$$

$$pV = nRT$$

$$\ln(p) = -\frac{\Delta H^\circ_{\text{vap}}}{T} + C$$

$$\ln(p_2/p_1) = -(\Delta H^\circ_{\text{vap}}/R) \{ (1/T_2) - (1/T_1) \}$$

$$p_A = X_A p_A^\circ$$

$$\Delta T_b = K_b m_B$$

$$[B] = k p_B$$

$$\Delta T_f = K_f m_B$$

$$\Delta p_A = X_B p_A^\circ$$

$$\Pi = [B]RT$$

$$H = U + pV$$

$$\Delta G_{\text{rxn}} = \Delta G^\circ_{\text{rxn}} + RT \ln Q$$

$$G = H - TS$$

$$\ln K = -\Delta G^\circ_{\text{rxn}}/RT$$

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

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

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

**GENERAL CHEMISTRY 2  
SECOND EXAM  
November 3, 2017**

**Name** \_\_\_\_\_ **KEY Version 2** \_\_\_\_\_

**Panthersoft ID** \_\_\_\_\_

**Signature** \_\_\_\_\_

**Part 1** \_\_\_\_\_ **(20 points)**

**Part 2** \_\_\_\_\_ **(32 points)**

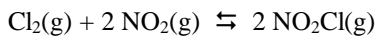
**Part 3** \_\_\_\_\_ **(48 points)**

**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]

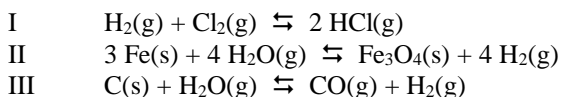
1) For the chemical reaction



$K_C = 1.8$  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  $\text{NO}_2\text{Cl}(\text{g})$  will increase
- b) The moles of  $\text{Cl}_2(\text{g})$  will increase
- A** c) The moles of  $\text{NO}_2(\text{g})$  will increase
- d) Both b and c
- e) None of the above

2) Consider the following three reactions



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

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

- a) KOH (potassium hydroxide)
- b) AgOH (silver hydroxide)
- A** c)  $\text{Ni}(\text{OH})_2$  (nickel II hydroxide)
- d) Both a and b
- e) Both a and b and c

4) From the substances HI,  $\text{H}_2\text{S}$ , and  $\text{H}_2\text{Se}$

- a) HI is the strongest acid and  $\text{H}_2\text{Se}$  is the weakest acid
- b) HI is the strongest acid and  $\text{H}_2\text{S}$  is the weakest acid
- B** c)  $\text{H}_2\text{S}$  is the strongest acid and HI is the weakest acid
- d)  $\text{H}_2\text{S}$  is the strongest acid and  $\text{H}_2\text{Se}$  is the weakest acid
- e)  $\text{H}_2\text{Se}$  is the strongest acid and  $\text{H}_2\text{S}$  is the weakest acid

5) In the reaction



the  $\text{Al}(\text{H}_2\text{O})_6^{3+}$  ion functions as

- a) the conjugate base of  $\text{H}_2\text{O}$
- b) the conjugate acid of  $\text{H}_2\text{O}$
- D** c) a Bronsted base
- d) a Bronsted acid
- e) none of the above

Version 1: C, E, C, E, B

Version 3: A, E, B, D, A

Version 4: C, D, B, A, C

**Part 2. Short answer.**

1) Consider the following chemical reaction



A system at constant volume containing CO, H<sub>2</sub>, and H<sub>2</sub>CO is initially at equilibrium. For each of the following changes to the system indicate whether the number of moles of H<sub>2</sub>CO 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

moles of H<sub>2</sub>CO  
increases

moles of H<sub>2</sub>CO  
remains the same

moles of H<sub>2</sub>CO  
decreases

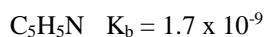
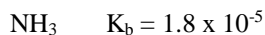
b) The temperature of the system is increased by 20.0 °C

moles of H<sub>2</sub>CO  
increases

moles of H<sub>2</sub>CO  
remains the same

moles of H<sub>2</sub>CO  
decreases

2) Values for K<sub>b</sub> for several weak bases are given below, at T = 25. °C.



From the lists below circle the correct answer. There is one and only one correct answer per problem. [4 points each]

a) The strongest weak base

NH<sub>3</sub>

(C<sub>2</sub>H<sub>5</sub>)<sub>2</sub>NH

C<sub>5</sub>H<sub>5</sub>N

C<sub>6</sub>H<sub>5</sub>NH<sub>2</sub>

b) The strongest conjugate acid

NH<sub>4</sub><sup>+</sup>

(C<sub>2</sub>H<sub>5</sub>)<sub>2</sub>NH<sub>2</sub><sup>+</sup>

C<sub>5</sub>H<sub>5</sub>NH<sup>+</sup>

C<sub>6</sub>H<sub>5</sub>NH<sub>3</sub><sup>+</sup>

3) An aqueous solution of a weak acid has pH = 5.18 at T = 25. °C. What are the values for pOH and [H<sub>3</sub>O<sup>+</sup>] for the solution? [4 points each]

pOH = \_\_\_\_\_ 8.82 \_\_\_\_\_

[H<sub>3</sub>O<sup>+</sup>] = \_\_\_\_\_ 6.6 x 10<sup>-6</sup> M \_\_\_\_\_

Version 1: pOH = 8.12, [H<sub>3</sub>O<sup>+</sup>] = 1.3 x 10<sup>-6</sup> M

Version 3: pOH = 9.75, [H<sub>3</sub>O<sup>+</sup>] = 5.6 x 10<sup>-5</sup> M

Version 4: pOH = 9.28, [H<sub>3</sub>O<sup>+</sup>] = 1.9 x 10<sup>-5</sup> M

4) Rubidium hydroxide (RbOH) is a strong soluble base. Find the pH of a 0.014 M aqueous solution of rubidium hydroxide at T = 25. °C. [8 points]

$$[\text{OH}^-] = \frac{0.014 \text{ mol RbOH}}{\text{L}} \frac{1 \text{ mol OH}^-}{1 \text{ mol RbOH}} = 0.014 \text{ M}$$

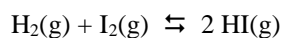
$$\text{pOH} = -\log_{10}[\text{OH}^-] = -\log_{10}(0.014) = 1.85$$

$$\text{pH} = 14.00 - \text{pOH} = 14.00 - 1.85 = 12.15$$

Version 1: pH = 12.73      Version 3: pH = 12.89      Version 4: pH = 12.58

### Part 3. Problems.

1) Using the information given below find the numerical values for  $\Delta G^\circ_{\text{rxn}}$  and K for the following reaction. You may assume that T = 25. °C. [16 points]



Substance	$\Delta H^\circ_f$ (kJ/mol)	$\Delta G^\circ_f$ (kJ/mol)	$S^\circ$ (J/mol·K)
H <sub>2</sub> (g)	0.00	0.00	130.68
HI(g)	26.48	1.70	206.59
I <sub>2</sub> (g)	62.44	19.33	260.69

$$\Delta G^\circ_{\text{rxn}} = [2 \Delta G^\circ_f(\text{HI}(\text{g}))] - [\Delta G^\circ_f(\text{H}_2(\text{g})) + \Delta G^\circ_f(\text{I}_2(\text{g}))]$$

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

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

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

2) Hypochlorous acid (HOCl) is a weak acid, with  $K_a = 3.5 \times 10^{-8}$  at  $T = 25.^\circ\text{C}$ .

a) Give the conjugate base of HOCl (correct formula and charge) [4 points]

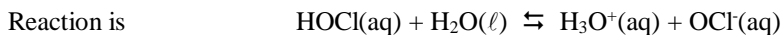
\_\_\_\_\_OCl<sup>-</sup>\_\_\_\_\_

Version 1: OBr<sup>-</sup>

Version 3: OCl<sup>-</sup>

Version 4: OBr<sup>-</sup>

b) What is the pH and the percent dissociation for a 0.00900 M aqueous solution of HOCl at  $T = 25.^\circ\text{C}$ ? [12 points]



$$K_a = \frac{[\text{H}_3\text{O}^+][\text{OCl}^-]}{[\text{HOCl}]} = 3.5 \times 10^{-8}$$

	Initial	Change	Equilibrium
H <sub>3</sub> O <sup>+</sup>	0	x	x
OCl <sup>-</sup>	0	x	x
HOCl	0.00900	- x	0.00900 - x

So  $\frac{(x)(x)}{(0.00900 - x)} = 3.5 \times 10^{-8}$

If we assume  $x \ll 0.00900$ , then we get

$$\frac{x^2}{(0.00900)} = 3.5 \times 10^{-8} \quad x^2 = (3.5 \times 10^{-8})(0.00900) = 3.15 \times 10^{-10}$$

$$x = (3.15 \times 10^{-10})^{1/2} = 1.78 \times 10^{-5}$$

$$\text{pH} = -\log_{10}(1.78 \times 10^{-5}) = 4.75$$

$$\% \text{ ionization} = \frac{[\text{OCl}^-]_{\text{eq}}}{[\text{HOCl}]_{\text{initial}}} \times 100\% = \frac{(1.78 \times 10^{-5})}{(0.00900)} \times 100\% = 0.20\%$$

Version 1: pH = 5.32, % dissociation = 0.05 %

Version 3: pH = 5.08, % dissociation = 0.42 %

Version 4: pH = 5.65, % dissociation = 0.11 %

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



A closed system at T = 1500. K initially has [F<sub>2</sub>] = 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? [16 points]

$$K_C = \frac{[\text{F}]^2}{[\text{F}_2]} = 0.064$$

	Initial	Change	Equilibrium
F	0	2x	2x
F <sub>2</sub>	0.1400	- x	0.1400 - x

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

If we assume  $x \ll 0.1400$ , then

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

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

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

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

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

The underlined root gives positive concentrations for F<sub>2</sub> and F.

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

Version 1: [F] = 0.073 M

Version 3: [F] = 0.086 M

Version 4: [F] = 0.093 M