

**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]														
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]						

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

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

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

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

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

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

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

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

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

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

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

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

$$pV = nRT$$

$$p_A = X_A p_A^\circ$$

$$\Delta T_b = K_b m_B$$

$$H = U + pV$$

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

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

$$[B] = k p_B$$

$$\Delta T_f = K_f m_B$$

$$G = H - TS$$

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

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

$$\Pi = [B]RT$$

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

**GENERAL CHEMISTRY 2  
SECOND EXAM**

**Name** \_\_\_\_\_

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

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

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

**Part 2** \_\_\_\_\_ (30 points)

**Part 3** \_\_\_\_\_ (30 points)

**TOTAL** \_\_\_\_\_ (80 points)

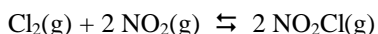
**Do all of the following problems. Show your work.**

**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 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

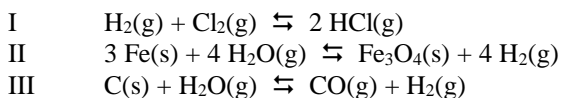
2) For the chemical reaction



$K_C = 1.8$  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

3) 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

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

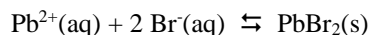
- a) KOH (potassium hydroxide)
- b) AgOH (silver hydroxide)
- A** c)  $\text{Ni}(\text{OH})_2$  (nickel II hydroxide)
- d) Both a and b
- e) Both a and b and c

5) The conjugate base of the  $\text{HSO}_4^-$  anion (hydrogen sulfate anion) is

- a)  $\text{H}_2\text{SO}_4$
- b)  $\text{HSO}_4^-$
- C** c)  $\text{SO}_4^{2-}$
- d)  $\text{H}_3\text{O}^+$
- e)  $\text{OH}^-$

**Part 2. Short answer.**

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



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

2) 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

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 \_\_\_\_\_

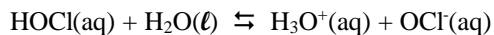
4) A solution is prepared by dissolving 18.45 g of potassium hydroxide (KOH, M = 56.11 g/mol), a strong soluble base, in water. The temperature of the solution is T = 25.0 °C, and the final volume of the solution is V = 400.0 mL. What is the pH of the solution? [6 points]

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

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

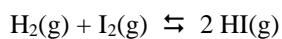
$$\text{But } [\text{KOH}] = [\text{OH}^{-}], \text{ so } [\text{OH}^{-}] = 0.822 \text{ mol/L} \quad \text{pOH} = -\log_{10}(0.822) = 0.085 \quad \text{pH} = 14.00 - \text{pOH} \\ = 14.00 - 0.085 = 13.91$$

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]



**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. [15 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

$$\begin{aligned} \Delta G^\circ_{\text{rxn}} &= [2 \Delta G^\circ_f(\text{HI}(\text{g}))] - [\Delta G^\circ_f(\text{H}_2(\text{g})) + \Delta G^\circ_f(\text{I}_2(\text{g}))] \\ &= [2 (1.70)] - [0.00 + 19.33] = - 15.93 \text{ kJ/mol} \end{aligned}$$

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

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

2) 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? [15 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

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

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

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

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

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