FORMULA SHEET (tear off)

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]

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

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

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

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

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

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

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

$H = U + pV$ | $G = H - TS$

GENERAL CHEMISTRY 2
FIRST 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. <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 statements concerning the thermodynamics of solution formation is correct?

a) ΔS_{soln} is usually much less than zero
b) ΔS_{soln} is usually much greater than zero
B c) ΔS_{soln} is usually about equal to zero
d) Both a and c
e) Both b and c

2) Which of the following aqueous solutions of strong electrolytes is expected to have the highest boiling point?

a) A 0.0100 mole/kg solution of potassium nitrate (KNO_3)
b) A 0.0100 mole/kg solution of iron(III) chloride ($FeCl_3$)
D c) A 0.0100 mole/kg solution of sodium sulfate (Na_2SO_4)
d) A 0.0200 mole/kg solution of calcium bromide ($CaBr_2$)
e) A 0.0200 mole/kg solution of sodium bromate ($NaBrO_3$)

3) A perfect crystal of which of the following pure substances will have S° = 0.0 J/mol•K at T = 0. K?

a) Fe (iron)
b) I_2 (iodine)
E c) ZnO (zinc II oxide)
d) Both a and b
e) Both a and b and c

4) For which of the following chemical reactions would you expect $\Delta S°_{rxn}$ to be positive at T = 25. °C?

a) $3\ O_2(g) \rightarrow 2\ O_3(g)$
b) $C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(\ell)$
C c) $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
d) Both b and c
e) None of the above

5) Which of the following substances should have the largest value for S° (standard molar entropy) at T = 25. °C?

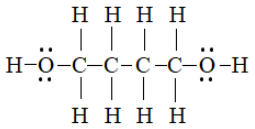
a) $N_2(g)$
b) $O_2(g)$
C c) NO(g)
d) Zn(s)
e) ZnO(s)

Part 2. Short answer questions.

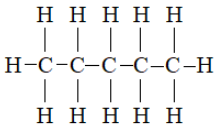
1) A solution is prepared by dissolving 4.183 g of copper II chloride ($CuCl_2$, MW = 134.45 g/mole) in water. The final volume of the solution is V = 250.0 mL. What is the molarity of copper II chloride in the solution? [6 points]

$$\text{moles } CuCl_2 = 4.183\ g \times \frac{1\ mol}{134.45\ g} = 0.03111\ mol \qquad \text{molarity} = \frac{0.0311\ mol}{0.2500\ L} = 0.1244\ M$$

2) 1,4-butanediol ($CH_2OHCH_2CH_2CH_2OH$) and n-pentane ($CH_3CH_2CH_2CH_2CH_3$) are both liquids at room temperature and pressure. Which of these molecules would you expect to be miscible with water? Why? Note that the Lewis structures of both molecules are shown below. [6 points]



$CH_2OHCH_2CH_2CH_2OH$



$CH_3CH_2CH_2CH_2CH_3$

Water is a poler liquid, and so is expected to be miscible with other polar liquids. n-pentane is a hydrocarbon, and so nonpolar, and so it will not mix well with water. 1,4-butanediol has two C-O-H groups, which contain polar O-H bonds, and so is a polar molecule, and therefore should be miscible with water.

3) A solution is formed by dissolving a 2.482 g of a nonvolatile solid in liquid benzene (C_6H_6, MW = 78.11 g/mol). The volume of the solution is V = 50.0 mL. The osmotic pressure of the solution relative to pure benzene, measured at T = 25.0 °C, was Π = 483. torr. What is the molecular weight of the nonvolatile solid? [10 points]

$\Pi = [B]RT$, and so $[B] = \frac{\Pi}{RT} = \frac{483.\ \text{torr}\ (1\ \text{atm}/760\ \text{torr})}{(0.08206\ \text{L·atm/mol·K})\ (298.2\ \text{K})} = 0.02597\ \text{mol/L}$

The moles of particles is moles particles = 0.0500 L (0.02597 mol/L) = 1.299×10^{-3} mol

Molecular weight is $MW = \frac{\text{grams solid}}{\text{moles solid}} = \frac{2.482\ \text{g}}{(1.299 \times 10^{-3}\ \text{mol})} = 1910\ \text{g/mol}$

4) Give the formation reaction for sodium nitrate ($NaNO_3(s)$). [4 points]

$Na(s) + \frac{1}{2}\ N_2(g) + \frac{3}{2}\ O_2(g) \rightarrow NaNO_3(s)$

5) What is the difference, if any, between a solution and a colloid? [4 points]

Both a solution and a colloid are homogeneous mixtures. However, in a solution the solute is made up of individual molecules or ions. In a colloid, the solute particles are a collection of a large number of molecules, and therefore can also differ in size. For example, in a fog (a colloid with water droplets suspended in air) the individual droplets of water will contain millions of water molecules per droplet.

Part 3. Problems

1) A solution of potassium chloride (KCl, MW = 74.55 g/mol) and water (H_2O, MW = 18.02 g/mol) has a density D = 1.078 g/mL. The mole fraction of potassium chloride in the solution is X_{KCl} = 0.0317. What is the molarity of potassium chloride in the solution? [14 points]

Assume 1.000 moles of solution. Then

moles KCl = 0.0317 moles

grams KCl = (0.0317 moles) $\frac{74.55\ g}{1\ mol}$ = 2.363 g

moles H_2O = 1.000 - 0.0317 = 0.9683 moles

grams H_2O = (0.9683 moles) $\frac{18.02\ g}{1\ mol}$ = 17.449 g

grams solution = grams KCl + grams H_2O = 2.363 g + 17.449 g = 19.812 g

liters solution = (19.812 g) $\frac{1\ mL}{1.078\ g}$ = 18.38 mL = 0.01838 L

molarity KCl = $\frac{\text{moles KCl}}{\text{L soln}}$ = $\frac{0.0317\ mol}{0.01838\ L}$ = 1.725 M

2) Consider the following chemical reaction

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

a) Find the numerical values for $\Delta G°_{rxn}$ and $\Delta S°_{rxn}$ for the reaction at T = 298. K. Thermochemical data at this temperature are given below and may be of use in doing this problem. [12 points]

Substance	$\Delta H°_f$(kJ/mol)	$\Delta G°_f$(kJ/mol)	S°(J/mol·K)
$Cl_2(g)$	0.00	0.00	222.96
NO(g)	90.25	86.57	210.65
NOCl(g)	51.71	66.07	261.6

$\Delta G°_{rxn} = [\ 2\ \Delta G°_f(NOCl(g))\ ] - [\ 2\ \Delta G°_f(NO(g)) + \Delta G°_f\ (Cl_2(g))\ ]$

$= [\ 2\ (66.07)\ ] - [\ 2\ (86.57) + (0.00)\ ] = -\ 41.00$ kJ/mol

$\Delta S°_{rxn} = [\ 2\ S°(NOCl(g))\ ] - [\ 2\ S°(NO(g)) + S°\ (Cl_2(g))\ ]$

$= [\ 2\ (261.6)\ ] - [\ 2\ (210.65) + (222.96)\ ] = -\ 121.1$ J/mol·K

b) Is the above reaction spontaneous for standard conditions and T = 298. K (yes/no/cannot tell)? Briefly justify your answer. [4 points]

Yes, the reaction is spontaneous.

For a reaction taking place for standard conditions the value for $\Delta G°_{rxn}$ determines whether or not the reaction is spontaneous. In the above reaction $\Delta G°_{rxn}$ is negative. Therefore, the reaction is spontaneous.