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]

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

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

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

$p_A = X_A p_A^\circ$ $\quad [B] = k p_B$ $\quad \Delta p_A = X_B p_A^\circ$

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

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

GENERAL CHEMISTRY 2
FIRST HOUR EXAM
SEPTEMBER 21, 2018

Name _____

Panthersoft ID _____

Signature _____

Part 1 _____ **(16 points)**

Part 2 _____ **(34 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 combinations of enthalpy and entropy changes is most likely to lead to the formation of a solution?

a) If $\Delta H°_{soln}$ is greater than zero and $\Delta S°_{soln}$ is greater than zero
b) If $\Delta H°_{soln}$ is greater than zero and $\Delta S°_{soln}$ is less than zero
C c) If $\Delta H°_{soln}$ is less than zero and $\Delta S°_{soln}$ is greater than zero
d) If $\Delta H°_{soln}$ is less than zero and $\Delta S°_{soln}$ is less than zero
e) Solution formation is equally likely for all of the above combinations of enthalpy and entropy change

2) A metal alloy is 0.085 % by mass chromium. The concentration of chromium in the alloy is also

a) 0.085 ppm by mass chromium
b) 8.5 ppm by mass chromium
C c) 850 ppm by mass chromium
d) 85000 ppm by mass chromium
e) None of the above

3) For a process to be spontaneous for standard conditions which of the following must be true?

a) $\Delta G°_{rxn} > 0$
b) $\Delta H°_{rxn} > 0$
E c) $\Delta S°_{rxn} > 0$
d) Both a and c
e) None of the above

4) For a particular chemical reaction both $\Delta H°_{rxn}$ and $\Delta S°_{rxn}$ are positive. Which of the following statements concerning the reaction is correct?

a) The reaction is expected to always be spontaneous
b) The reaction is expected to never be spontaneous
c) The reaction is expected to be spontaneous at low temperatures, but not at high temperatures
d) The reaction is expected to be spontaneous at high temperatures, but not at low temperatures
e) No prediction can be made about when the reaction is or is not spontaneous

Part 2. Short answer.

1) A solution is formed by dissolving 18.7 g of sodium bromide (NaBr, MW = 102.9 g/mol) in water. The final volume of the solution is V = 400.0 mL. What is the molarity of NaBr in the solution? [6 points]

$$\text{moles NaBr} = 18.7\ \text{g} \times \frac{1\ \text{mol}}{102.9\ \text{g}} = 0.1817\ \text{mol}$$

$$\text{molarity} = \frac{0.1817\ \text{mol}}{0.4000\ \text{L}} = 0.454\ \text{mol/L}$$

2) Define the following terms [4 points each]

solvent

The major component in a solution.

state function

A function whose change in value depends only on the initial and final state of the system, and which is independent of the pathway used to travel between these states.

3) The molality of carbon disulfide (CS_2, MW = 76.14 g/mol) in a liquid solution of carbon disulfide and toluene ($C_6H_5CH_3$, MW = 92.13 g/mol) is m = 1.748 mol/kg. What is the mole fraction of carbon disulfide in the solution? [8 points]

Assume 1.000 kg toluene. Then there are 1.748 moles of CS_2.

The moles of toluene is then $1000.0\ g \times \frac{1\ mol}{92.13\ g} = 10.854\ mol\ toluene$

The mole fraction of CS_2 is then $X(CS2) = \frac{1.748\ mol}{(1.748 + 10.854)\ mol} = 0.1387$

4) Give the correctly balanced formation reaction for iron pentacarbonyl ($Fe(CO)_5(\ell)$). [4 points]

$$Fe(s) + 5\ C(s) + {}^5/_2\ O_2(g) \rightarrow Fe(CO)_5(\ell)$$

5) Complete the chart below by providing the missing information. [4 points each]

ΔS_{syst} (J/mol·K)	ΔS_{surr} (J/mol·K)	ΔS_{univ} (J/mol·K)	Is the process spontaneous? (yes or no)
+ 91.7	__- 106.0_____	- 14.3	_____no_____

Part 3. Problems.

1) A solution is prepared by dissolving 4.48 g of a nonvolatile solute in 160.00 g of liquid benzene (C_6H_6, MW = 78.11 g/mol).

a) Will the vapor pressure of benzene in the above solution be higher than, equal to, or lower than the vapor pressure of pure benzene at the same temperature? [4 points]

Lower.

b) The normal boiling point for the above solution is 0.44 °C higher than the boiling point of pure benzene. What is the molality of solute in the solution? Note that for benzene K_b = 2.62 kg•°C /mol. [6 points]

$\Delta T_b = K_b\, m_B$ $\qquad$ $m_B = \dfrac{\Delta T_b}{K_b} = \dfrac{0.44\ °C}{2.62\ kg•°C/mol} = 0.1679\ mol/kg$

c) Based on the above information, what is the molecular weight of the solute? [8 points]

moles solute = (0.1679 mol/kg) (0.1600 mol) = 0.02686 mol

$MW = \dfrac{4.48\ g}{0.02686\ mol} = 167.\ g/mol$

2) Thermodynamic data are given below (at T = 25. °C) and may be of use in doing this problem.

Substance	$\Delta H°_f$ (kJ/mol)	$\Delta G°_f$ (kJ/mol)	$S°$ (J/mol·K)
$CO_2(g)$	- 393.5	- 394.4	213.7
$C_2H_5OH(\ell)$	- 277.7	- 174.9	160.7
$C_6H_{12}O_6(s)$	- 1273.3	- 910.4	212.1

The fermentation of glucose ($C_6H_{12}O_6$, MW = 180.2 g/mol) can produce ethyl alcohol by the process

$C_6H_{12}O_6(s) \rightarrow 2\ C_2H_5OH(\ell) + 2\ CO_2(g)$

a) What are $\Delta S°_{rxn}$ and $\Delta G°_{rxn}$ for the above reaction at T = 25. °C (including units)? [8 points]

$\Delta S°_{rxn} = [\ 2\ S°(C_2H_5OH(\ell)) + 2\ S°(CO_2(g))\ ] - [\ S°(C_6H_{12}O_6(s))\ ]$

$= [\ 2\ (160.7) + 2\ (213.7)\ ] - [\ (212.1)\ ] = 536.7$ J/mol·K

$\Delta G°_{rxn} = [\ 2\ \Delta G°_f(C_2H_5OH(\ell)) + 2\ \Delta G°_f(CO_2(g))\ ] - [\ \Delta G°_f(C_6H_{12}O_6(s))\ ]$

$= [\ 2\ (-174.9) + 2\ (-394.4)\ ] - [\ (-910.4)\ ] = -228.2$ kJ/mol

b) Is the above reaction spontaneous for standard conditions and T = 25. °C? Briefly justify your answer. [4 points]

Since $\Delta G°_{rxn} < 0$, the reaction is spontaneous for standard conditions and at T = 25. °C.