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]

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

1 amu = 1.661×10^{-27} kg

1 atm = 760 torr = 760 mm Hg

$R = 0.08206$ L·atm/mol·K

$R = 8.314$ J/mol·K

$°C = (^5/_9)(°F - 32)$

$°C = K - 273.15$

1 atm = 1.013 bar

1 L·atm = 101.3 J

1 J= 1 kg·m^2/s^2

$°F = (^9/_5)(°C) + 32$

$K = °C + 273.15$

$pV = nRT$

$p_A = X_A p_A°$

$\Delta T_b = K_b m_B$

$[B] = k p_B$

$\Delta T_f = K_f m_B$

$\Delta p_A = X_B p_A°$

$\Pi = M_B RT$

$H = U + pV$

$G = H - TS$

GENERAL CHEMISTRY 2
FIRST HOUR EXAM
FEBRUARY 11, 2022

Name _____

Panthersoft ID _____

Signature _____

Part 1 _____ **(20 points)**

Part 2 _____ **(43 points)**

Part 3 _____ **(37 points)**

TOTAL _____ **(100 points)**

Unless otherwise stated, you may assume T = 25.0 °C in all of the problems below.

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) A solution is formed by dissolving 4.78 g of methyl alcohol (CH_3OH, MW = 32.04 g/mol) and 28.53 g of water (H_2O, MW = 18.02 g/mol) in 485.1 g of ethyl alcohol (C_2H_5OH, MW = 46.07 g/mol). Which of the following is the solvent in the above solution?

a) methyl alcohol
b) ethyl alcohol
B c) water
d) Both a and b
e) Both a and c

2) The value for the constant k in Henry's Law ($[B] = k\ p_B$) depends on which of the following?

a) The identity of the solute
b) The identity of the solvent
E c) Temperature
d) Both a and b
e) Both a and b and c

3) Which of the following is not a colligative property?

a) Boiling point elevation
b) Freezing point depression
C c) Raoult's Law
d) Vapor pressure lowering
e) Osmotic pressure

4) For a process to occur spontaneously which of the following must be true?

a) $\Delta S_{syst} > 0$
b) $\Delta S_{surr} > 0$
C c) $\Delta S_{univ} > 0$
d) Both a and b
e) Both a and b and c

5) For which of the following pure chemical substance is $S° = 0.0$ J/mol•K at T = 25. °C?

a) Aluminum (Al(s))
b) Nitrogen ($N_2(g)$)
E c) Sulfur dioxide ($SO_2(g)$)
d) Both a and b
e) None of the above

Part 2. Short answer.

1) Define the following term: heterogeneous mixture [5 points]

A heterogeneous mixture is a physical combination of two or more pure chemical substances where different regions have different compositions. Example: A mixture of sand (SiO_2) and sugar ($C_6H_{12}O_6$).

2) A solution is formed by dissolving 0.0126 g of a nonvolatile and nonionizing solute in water (H_2O, MW = 18.02 g/mol). The final volume of the solution is V = 20.00 mL. The osmotic pressure of the solution (relative to pure water) is Π = 83. torr at T = 35. °C. What is the molecular weight of the solute? [12 points]

$$MW = \frac{m}{n} = \frac{\text{grams}}{\text{moles}}$$

$$\Pi = M_B RT \qquad \text{so } M_B = \frac{\Pi}{RT} = \frac{(83 \text{ torr})(1 \text{ atm}/760 \text{ torr})}{(0.08206 \text{ L·atm/mol·K})(308.2 \text{ K})} = 4.32 \times 10^{-3} \text{ mol/L}$$

So $n = M_B V = (4.32 \times 10^{-3} \text{ mol/L})(0.02000 \text{ L}) = 8.64 \times 10^{-5}$ mol

And so $MW = \frac{0.0126 \text{ g}}{8.64 \times 10^{-5} \text{ mol}} = 146. \text{ g/mol}$

3) Give the correctly balanced formation reaction for gold III hydroxide ($Au(OH)_3(s)$). [5 points]

$$Au(s) + {}^3/_2\, O_2(g) + {}^3/_2\, H_2(g) \rightarrow Au(OH)_3(s)$$

4) The molality of a solution of acetone (CH_3COCH_3, MW = 58.08 g/mol) in n-hexane (C_6H_{14}, MW = 86.18 g/mol) is m = 2.317 mol/kg. What is the percent by mass acetone in the solution? [9 points]

Assume 1.0000 kg = 1000.0 g n-hexane (the solvent)

Then mol acetone = $\frac{2.317 \text{ mol}}{\text{kg}} \times 1 \text{ kg} = 2.317 \text{ mol}$

Gram acetone = $2.317 \text{ mol} \times \frac{58.08 \text{ g}}{\text{mol}} = 134.6 \text{ g acetone}$

So the percent by mass acetone = $\frac{\text{mass acetone}}{\text{mass acetone + mass n-hexane}} \times 100\ \%$

$= \frac{134.6 \text{ g}}{134.6 \text{ g} + 1000.0 \text{ g}} \times 100\ \% = 11.9\ \%$ acetone by mass

5) For each of the following provide the missing information by filling in the blank. Include correct units. You may assume T = 25. °C. [6 points each]

a) $\Delta S_{univ} = 34.7$ J/mol·K $\Delta S_{syst} = 41.5$ J/mol·K

ΔS_{surr} = _____– 6.8 J/mol·K_____

b) $\Delta S°_{rxn} = -144.6$ J/mol·K $\Delta G°_{rxn} = 152.8$ kJ/mol

$\Delta H°_{rxn}$ = _____109.7 kJ/mol_____

$\Delta S_{univ} = \Delta S_{syst} + \Delta S_{surr}$ $\Delta S_{surr} = \Delta S_{univ} - \Delta S_{syst}$

$\Delta G°_{rxn} = \Delta H°_{rxn} - T\,\Delta S°_{rxn}$ $\Delta H°_{rxn} = \Delta G°_{rxn} + T\,\Delta S°_{rxn}$

1) At T = 20. °C, n-pentane (C_5H_{12}, MW = 72.15 g/mol) and n-hexane (C_6H_{14}, MW = 86.18 g/mol) form an ideal solution. The vapor pressures for the pure liquids at this temperature are $p_p° = 372.8$ torr for n-pentane and $p_h° = 107.0$ torr for n-hexane.

a) Which pure liquid has the higher value for S° at T = 20. °C, n-pentane or n-hexane? Give a brief justification for your answer. [5 points]

n-hexane. For similar molecules in the same phase, the larger molecule has more ways to arrange itself, and so has more randomness and a larger value for S°.

b) Do n-pentane and n-hexane obey Raoult's law in the above solution (yes/no and a brief justification for your answer)? [5 points]

Yes. By definition, an ideal solution is a solution where each component obeys Raoult's law.

c) The partial pressure of n-pentane above a solution of n-pentane and n-hexane at T = 20. °C is $p_p = 156.$ torr. What is the partial pressure of n-hexane above the solution? [12 points]

Since both liquids obey Raoult's law

$p_p = X_p\, p_p°$ $\qquad X_p = \dfrac{p_p}{p_p°} = \dfrac{156.\text{ torr}}{372.8\text{ torr}} = 0.4185$

$X_p + X_h = 1$, and so $X_h = 1 - X_p = 1 - 0.4185 = 0.5815$

And so $p_h = X_h\, p_h° = (0.5815)\,(107.0\text{ torr}) = 62.2\text{ torr}$

The data below is given at T = 25.0 °C, and may be of use in doing the following problem.

substance	$\Delta H°_f$ (kJ/mol)	$\Delta G°_f$ (kJ/mol)	$S°$ (J/mol·K)
$F^-(aq)$	– 332.6	– 278.8	– 13.8
$Pb^{2+}(aq)$	– 1.7	– 24.4	10.5
$PbF_2(s)$	– 664.0	– 617.1	110.5

2) Pb^{2+} ion can be removed from aqueous solution by reaction with fluoride ion. The balanced reaction is

$Pb^{2+}(aq) + 2\ F^-(aq) \rightarrow PbF_2(s)$

a) What are $\Delta S°_{rxn}$ and $\Delta G°_{rxn}$ for the above reaction (including units)? [10 points]

$\Delta S°_{rxn} = [\ S°(PbF_2(s))\ ] - [\ S°(Pb^{2+}(aq)) + 2\ S°(F^-(aq))\ ]$

$= [\ 110.5\ ] - [\ (\ 10.5) + 2\ (-13.8)\ ] = 127.6$ J/mol·K

$\Delta G°_{rxn} = [\ \Delta G°_f(PbF_2(s))\ ] - [\ \Delta G°_f(Pb^{2+}(aq)) + 2\ \Delta G°_f(F^-(aq))\ ]$

$= [\ -617.1\ ] - [\ (-24.4) + 2\ (-278.8)\ ] = -35.4$ kJ/mol

b) Is the above reaction spontaneous for standard conditions and T = 25.0 °C? (yes or no, and a brief justification for your answer). [5 points]

YES. For a chemical reaction at standard conditions the reaction is spontaneous if $\Delta G°_{rxn} < 0$ Since $\Delta G°_{rxn} = -35.4$ kJ/mol, the reaction is spontaneous.