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
SEPTEMBER 24, 2021

Name _____

Panthersoft ID _____

Signature _____

Part 1 _____ **(20 points)**

Part 2 _____ **(42 points)**

Part 3 _____ **(38 points)**

TOTAL_____ **(100 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 will make it more likely that a mixture of two liquids will form a solution?

a) An increase in energy when the liquids form a solution
b) An increase in randomness when the liquids form a solution
B c) A decrease in randomness when the liquids form a solution
d) Both a and b
e) Both a and c

2) Which of the following combinations of two liquids is likely to form a solution?

a) A combination of two polar liquids
b) A combination of two nonpolar liquids
D c) A combination of a polar liquid and a nonpolar liquid
d) Both a and b
e) Both b and c

3) A sample of a metal alloy has a mass of 273.5 g. It contains 473. ppm by mass cobalt. The number of grams of cobalt in the metal alloy is

a) 0.0129 g
b) 0.129 g
B c) 1.29 g
d) 12.9 g
e) 129. g

4) For a chemical reaction taking place at a constant temperature and standard conditions, which of the following must be true?

a) $\Delta G°_{rxn} < 0$
b) $\Delta G°_{rxn} > 0$
A c) $\Delta S°_{rxn} > 0$
d) Both a and c
e) Both b and c

5) For a particular chemical reaction the values for $\Delta H°_{rxn}$ is positive, and the value for $\Delta S°_{rxn}$ is negative. Based on this information we would expect

a) The reaction is spontaneous at low temperatures, but not at high temperatures
b) The reaction is spontaneous at high temperatures, but not at low temperatures
D c) The reaction is always spontaneous
d) The reaction is never spontaneous
e) Any of the above might be expected to be true

Part 2. Short answer.

1) Define the following terms [4 points each]

a) heterogeneous mixture – A physical combination of two or more pure chemical substances, where the composition is different in different regions of the mixture.

b) Third Law of Thermodynamics – The entropy of any pure chemical substance at absolute zero is exactly equal to 0.0 J/mol•K

2) The figure below is for a mixture of two volatile liquids A and B, at T = 40.0 °C. Based on the information in the figure, answer the following questions? [4 points each]

a) Do A and B form an ideal solution (yes or no, and a brief justification for your answer)?

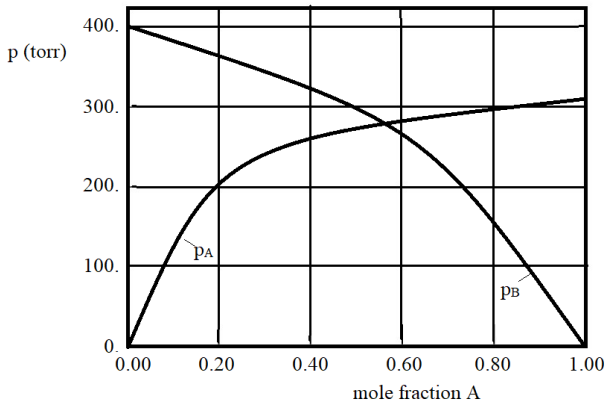
NO. For an ideal solution the components both obey Raoult's law, which would cause the relationship between pressure and mole fraction to be linear. The figure shows a curved relationship, and so the solution is not ideal.

b) What is $p_B°$, the vapor pressure of pure B? Give your final answer in units of torr.

$p_B° = 400$ torr

c) What is p_B, the partial pressure of B, for a solution with $X_A = 0.40$? Give your final answer in units of torr.

$p_B = 320$ torr



3) A solution is formed by dissolving 13.81 g of glucose ($C_6H_{12}O_6$, MW = 180.2 g/mol) in water (H_2O, MW = 18.02 g/mol). The final volume of the solution is V = 250.0 mL. What is the molarity of glucose in the solution? [8 points]

$$\text{molarity} = \frac{\text{moles glucose}}{\text{liters solution}}$$

$$\text{moles glucose} = 13.81\ \text{g} \times \frac{1\ \text{mol}}{180.2\ \text{g}} = 7.663 \times 10^{-2}\ \text{mol}$$

$$\text{liters solution} = 0.2500\ \text{L}$$

$$\text{molarity} = \frac{7.663 \times 10^{-2}\ \text{mol}}{0.2500\ \text{L}} = 0.3065\ \text{mol/L}$$

4) Give the formation reaction for nickel II carbonate ($NiCO_3(s)$). [5 points]

$$Ni(s) + C(s) + {}^3/_2\ O_2(g) \rightarrow NiCO_3(s)$$

5) Consider the following process (called fusion, or melting) involving an unknown metal M.

$$M(s) \rightarrow M(\ell)$$

The change in enthalpy and the change in entropy for the process, measured for standard conditions and T = 25.0 °C, are $\Delta H°_{fus}$ = 6.68 kJ/mol, and $\Delta S°_{fus}$ = 9.17 J/mol•K.

a) Which phase of the metal has a larger value for entropy at standard conditions and T = 25.0 °C, the solid or the liquid (circle the correct answer). [4 points]

M(s) has the larger value for S°

M(ℓ) has the larger value for S°

b) Estimate the value for $T°_{fus}$, the normal melting point for the metal. Give your final answer in units of °C. [5 points]

At equilibrium, $\Delta G°_{fus} = 0 = \Delta H°_{fus} - T\Delta S°_{fus}$, and so $T°_{fus} \cong \frac{\Delta H°_{fus}}{\Delta S°_{fus}}$

$$\text{So } T°_{fus} = \frac{6680.\ \text{J/mol}}{9.17\ \text{J/mol•K}} = 728.5\ \text{K} = 455.\ °\text{C}$$

Part 3. Problems.

1) A solution is prepared by dissolving 30.83 g of a nonvolatile and nonionizing pure chemical compound X in benzene (C_6H_6, MW = 78.11 g/mol). The final mass of the solution is mass = 605.2 g, and the molality of X in the solution is m_X = 0.3627 mol/kg.

a) Based on this information, find the molecular weight of X. [12 points]°

$$MW = \frac{\text{grams X}}{\text{moles X}} \qquad \text{grams X} = 30.83 \text{ g}$$

To find the moles of X we need to find the kg of solvent.

Since g soln = g solvent + g X , g solvent = g soln – g X = 605.2 g – 30.83 g = 574.37 g solvent

Now we can use the molality to find the moles X

$$\text{moles X} = 0.\frac{3627 \text{ mol X}}{\text{kg solvent}} \times 574.37 \text{ g solvent} = 0.2083 \text{ mol X}$$

And so $MW = \frac{30.83 \text{ g X}}{0.2083 \text{ mol X}} = 148.0$ g/mol

b) The normal freezing point for benzene is $T_f°$ = 5.5 °C, and the freezing point depression constant for benzene is K_f = 5.12 kg•°C/mol. Based on this information and the other information given in the problem, find the freezing point temperature for the solution of X + benzene. Give your final answer in units of °C. [8 points]

For freezing point depression, $\Delta T_f = K_f m_B$

So ΔT_f = (5.12 kg•°C/mol) (0.3627 mol/kg) = 1.86 °C

Freezing point for the solution is lower than that of the pure liquid, and so

T_f = 5.5 °C – 1.86 °C = 3.6 °C

2) Thermochemistry is often used to study the behavior of ions in aqueous solution. Consider the following process involving sodium sulfate (Na_2SO_4)

$Na_2SO_4(s) \rightarrow 2\ Na^+(aq) + SO_4^{2-}(aq)$

a) What is the value for i, the van't Hoff factor, for sodium sulfate? Circle the correct answer. [4 points]

i = 1 i = 2 **i = 3** i = 4

b) Based on the data below, find the value for $\Delta S°_{rxn}$ and $\Delta G°_{rxn}$ for the above reaction, at T = 25.0 °C. The data in the table below is also given at T = 25.0 °C. [10 points]

substance	$\Delta H°_f$ (kJ/mol)	$\Delta G°_f$ (kJ/mol)	$S°$ (J/mol·K)
$Na^+(aq)$	– 240.1	– 261.9	59.0
$SO_4^{2-}(aq)$	– 909.3	– 744.5	20.1
$Na_2SO_4(s)$	– 1387.1	– 1270.2	149.6

$\Delta S°_{rxn} = [\ 2\ S°(Na^+(aq)) + S°(SO_4^{2-}(aq))\ ] - [\ S°(Na_2SO_4(s))\ ]$

$= [\ 2\ (59.0) + (20.1)\ ] - [\ (149.6)\ ] = -\ 11.5$ J/mol·K

$\Delta G°_{rxn} = [\ 2\ \Delta G°_f(Na^+(aq)) + \Delta G°_f(SO_4^{2-}(aq))\ ] - [\ \Delta G°_f(Na_2SO_4(s))\ ]$

$= [\ 2\ (-\ 261.9) + (-\ 744.5)\ ] - [\ (-\ 1270.2)\ ] = +\ 1.9$ kJ/mol

c) Is the above reaction spontaneous for standard conditions and T = 25.0 °C? (yes or no, and a brief justification for your answer). [4 points]

NO, because $\Delta G°_{rxn} > 0$.