1. What is the mole fraction of ethyl alcohol (C_2H_6O, density = 0.790 g/ml, MW= 46.08 g/mol) in water (MW=18.02 g/mol) for a solution made from equal volumes of each? (5 points)

2. Industrial grade concentrated HCl (MW= 36.46 g/mol) is known as muriatic acid and is 31.45% by mass HCl in water. What is the molality of this solution? (5 points)

3. List the following in order of solubility in hexane: (3 points)
      a. $CH_3CH_2C(O)CH_3$ b. C_6H_6
      c. $CH_3CH_2CH_2CO_2H$ d. $CH_3CH_2CH_2CH_2CO_2H$

            >   >   >

4. Calculate the following: (each 5 points)
(a) the mass of CO_2 that dissolve in 225 mL of a carbonated beverage at 1.10 atm pressure and 25 °C; and (b) the partial pressure of CO_2 in the gas space above the liquid if a bottle of this carbonated beverage is stored in an ice chest at 0.0 °C. (K_H for CO_2 is 3.4 x 10^{-2} M/atm at 25°C and 7.8 x 10^{-2} M/atm at 0.0°C)?

5. Vodaka is 35% by mass ethanol (C_2H_5OH: Mw=46.07 g/mol) and has a density of 0.94 g/ml. Assuming no other components other than water, calculate the mole fraction, molarity, and molality of Vodaka. (5 points)

6. Hard candy is made from very hot solutions of sugar and water with small amounts of added flavorings. In a typical preparation, the boiling point of the sugar/water mixture reaches 145 °C. What mass ratio of sugar ($C_{12}H_{22}O_{11}$: MW= 342 g/mol) to water is required to raise the boiling point of a sugar/water solution to 145°C? (5 points) K_b = 1.858 °C kg/mol,
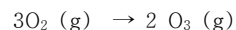
7. Fungal laccase is an enzyme found in fungi that live on rotting wood. The enzyme is blue and contains 0.40 % by mass copper. The molar mass of the enzyme is approximately 64,000 g/mol. How many copper atoms are there in one molecule of fungal laccase? (Cu Mw: 63.55 g/mol) (5 points)

8. For the following constant-temperature process, give the sign (+, −, or 0) for each of the specified thermodynamic functions. In each case give a brief account of your reasoning: (5 points)
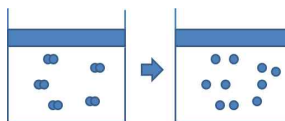
(a) W_{sys}
(b) q_{sys}
(c) ΔS_{surr}

9. In the upper atomsphere, ozone is produced from oxygen :
                                  (each 5 points)
$$3O_2 (g) \rightarrow 2 O_3 (g)$$
   $\Delta H°$ reaction = 285,4 kJ
   $\Delta S°$ reaction = −137.7 J/K
   $\Delta G°$ reaction = 326.4 kJ

(a) Is there a temperature at which this reaction becomes spontaneous at 1 bar pressure? If so, find it. If not, explain why one does not exist.

(b) Assume an atmosphere with PO_2 = 0.20 bar and T=298 K. Below what pressure of O_3 is O_3 production spontaneous?

10. Humans perspire as a way of keeping their bodies from overheating during strenuous exercise. The evaporation of perspiration transfers heat from the body to the surrounding atmosphere. Calculate the total ΔS for evaporation of 1.0 g of water if the skin is at 37.5°C and air temperature is 23.5°C. (5 points)

11. Arrange the following in order of increasing entropy, from smallest to largest value: (a) 1.0 mol H_2O (liquid, 373 K); (b) 0.50 mol H_2O (liquid, 298 K); (c) 1.0 mol H_2O (liquid, 298 K); (d) 1.0 mol H_2O (gas, 373 K, 1 bar); and (e) 1.0 mol H_2O (gas, 373 K, 0.1 bar); (2 points)

　　　　　　　 > 　　 > 　　 > 　　 >

12. At 45℃, what is the vapor pressure of Iodine?

　　　($I_2(s)$: $\Delta H° = 0$,　$S° = 116.1$ J/mol·K)

　　　($I_2(g)$: $\Delta H° = 62.4$ kJ/mol,　$S° = 260.7$ J/mol·K)

　(10 points)

13. One of the more important industrial chemicals is hydrogen. One process for hydrogen production is called "steam reforming", in which hydrocarbons react with water to give hydrogen and CO. The equation of reaction for reforming methane is written below. (each 5 points)
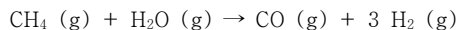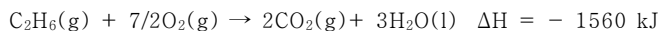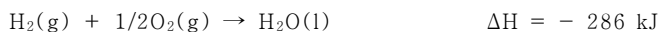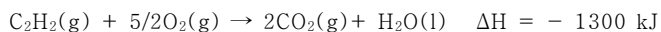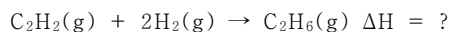
　　　$CH_4 (g) + H_2O (g) \rightarrow CO (g) + 3 H_2 (g)$

Chemical	CH_4 (g)	H_2O (g)	CO (g)	H_2 (g)
$\Delta G°$	–50.5	–228.7	–137.2	0
$\Delta H°$	–74.6	–241.8	–110.5	0
$S°$	186.3	188.8	197.7	130.7

　(a) Calculate the free energy change for this reaction at standard conditions.

　(b) Estimate the temperature at which the process becomes spontaneous.

14. Calculate the ΔH of this reaction.　　(10 points)

　　　$C_2H_2(g) + 2H_2(g) \rightarrow C_2H_6(g)$　$\Delta H = ?$

$C_2H_2(g) + 5/2O_2(g) \rightarrow 2CO_2(g) + H_2O(l)$　$\Delta H = -1300$ kJ
$H_2(g) + 1/2O_2(g) \rightarrow H_2O(l)$　　　　　　$\Delta H = -286$ kJ
$C_2H_6(g) + 7/2O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$　$\Delta H = -1560$ kJ

15. The boiling point of an aqueous solution containing Sucrose ($C_{12}H_{22}O_{11}$ = 342 g/mol) is 101.45 ℃. Calculate the osmotic pressure of this solution at 35 ℃ at which the solution density is 1.036 g/mL.　(10 points)

　(K_b = 0.512 ℃ kg/mol)

**************** 문제 해결에 필요한 상수들 **************

● 0 K = − 273.15 ℃

● 기체 상수 R = 8.314 J mol^{-1} K^{-1}　;
　　　　　　　　R = 8.206 × 10^{-2} L atm mol^{-1} K^{-1}

● 물 (H_2O)의 MW = 18.01 g/mol
　　　　　　density = 1.00 g/ml
　　　　　　B.P = 100.00 ℃
　Cl : 35.45 g/mol
　H : 1.01 g/mol
　C : 12.01 g/mol
　O : 16.00 g/mol

● $\ln vp = -\dfrac{\Delta H}{RT} + \dfrac{\Delta S}{R}$

● Standard $S°$
　H_2 (g) : 130.680 J mol^{-1} K^{-1}
　C_2H_2 (g) : 229.2 J mol^{-1} K^{-1}
　N_2 (g) 191.61 J mol^{-1} K^{-1}