1. 在一大氣壓(1atm)平衡下, 鉛的熔點為 600K, 而且在此溫度鉛的熔化潛熱(latent heat of melting)為 4810J/mole. 請計算當 1 莫耳的過冷(supercooled)液態鉛在氣壓為 1atm, 溫度為 590K, 自發地凝凍所引起的 entropy 變化. 在 1atm 之下, 液態鉛和固態鉛的定壓比熱分別為 $c_{p(l)} = 32.4 - 3.1 \times 10^{-3}\,T$ J/K; $c_{p(s)} = 9.75 \times 10^{-3}\,T$ J/K, 其中 T 為溫度. (10 points)

2. 請由熱力學第二定律, 在定壓的條件下, 導出 Gibbs Free Energy Function

   $G = H - TS$ (10 points)

3. 將一莫耳的高分子, 聚苯乙烯(polystyrene), 由室溫非常緩慢地降到絕對零度(0K). 已知此高分子為不結晶的非晶態(amorphous)高分子, 請問在 0K 時, 此高分子之 entropy 是否為零? 為什麼? 你的答案和熱力學第三定律事否有所抵觸? (10 points)

4. 已知在氣壓為 1atm, 溫度為 300K 之平衡狀態下, 5 莫耳的某氣體之 entropy 為 240J/K. 以非常緩慢, 不打擾此系統的平衡狀態下, 將 1 莫耳的氣體由其中分離出來, 請問此分離出來的氣體之 entropy 為多少? 由您計算出來的 entropy, 您如何據以判斷此氣體之分子結構? (10 points)

5. 請解釋:
   a. Debye Temperature (3 points)
   b. Vibrational Entropy 和 Configurational Entropy (4 points)
   c. Carnot Cycle (3 points)

6. When working with gas mixtures we often use the approximation that the gas mixture is ideal. However, when studying condensed phases, we have stated that the ideal solution model is inappropriate.

a. Define what is meant by ideal behavior for a gas mixture or a condensed phase solution in terms of the chemical potential of the components. (5%)

b. Explain how you might incorporate nonideal behavior to describe a gas mixture. In your answer state what experimental data would be required and how it would be used to modify the chemical potential. (5%)

c. Explain how you might incorporate nonideal behavior to describe condensed phase solutions. In your answer state what experimental data you would require and how it would be used to modify the chemical potential. (5%)

d. Is the chemical potential of an ion in solution a physically meaningful quantity? Explain your answer. If you answer yes, explain how it could be determined experimentally. If you answer no, explain how we are able to tabulate values of $\Delta_f G^0$ for ions. (10%)

7. A container whose volume is V liters contains an equilibrium mixture of 2 moles of PCl_5, 2 moles PCl_3 and 2 moles of Cl_2 (all gases). The pressure is 3 atm and the temperature is T°K. A certain amount of Cl_2 is added, keeping pressure and temperature constant, until a new equilibrium volume of 2V liters is reached. How many moles of Cl_2 were added? What is the value of the equilibrium constant, K, for this reaction? (15%).

8. (a) The vapor pressure of water at 298K is 23.76 torr. What is the Gibbs free energy at one atm for the change of $H_2O(g) \rightarrow H_2O(l)$? (5%)

(b) The boiling point of pure toluene is 110.60 °C. A solution containing 5.0 gm diphenyl, $C_{12}H_{10}$ in 100 gm toluene boils at 111.68 °C. A solution containing 6.0 gm of an unknown nonvolatile substance in 200 gm toluene boils at 112.0 °C. Calculate the mass per mole of the unknown. (5%)