1. One mole of an ideal gas undergoes a free adiabatic expansion from V = 1 liter at 25 $^{\circ}$C to V = 6 liters. Calculate ΔE, ΔH, ΔS, Q and ΔG. (10 %)

2. A cold engine operating at 25 $^{\circ}$C is employed to maintain a cold storage at −20 $^{\circ}$C. What is the minimum amount of work needed to withdraw 500 Joules of heat from the storage? (10 %)

3. $C_P - C_v = T \cdot (\frac{\partial P}{\partial T})_V \cdot (\frac{\partial V}{\partial T})_P$, prove $C_P - C_v = R$ for ideal gas. (10 %)

4. The enthalpy change for the reaction, Sn (grey) $\rightarrow$ Sn (white), is 0.7 kcal at 25 $^{\circ}$C. The entropy change is 1.8 cal/deg. Assuming ΔH^0 and ΔS^0 to be independent of temperature, calculate the temperature at which grey and white Sn coexist in equilibrium. (10 %)

5. One mole of $CH_{4(g)}$ and one mole of $CO_{2(g)}$ are mixed and allowed to react at 1000 K and 1 atm pressure to form $H_2(g)$ and CO(g). Determine the number of moles of each gas. Given that the standard free energy of the reaction at 1000 K, ΔG° = -2×10^4 J/mole for CH_4. (10 %)

6. The standard reaction enthalpy for the hydrogenation of propene is -124 KJmol^{-1}.
   CH_2=CHCH$_3$ (g) + H$_2$ (g) $\rightarrow$ CH$_3$CH$_2$CH$_3$ (g)
   The standard reaction enthalpy for the combustion of propane is -2220 KJmol^{-1}.
   CH$_3$CH$_2$CH$_3$ (g) + 5 O$_2$ (g) $\rightarrow$ 3 CO$_2$(g) + 4 H$_2$O (l)
   The standard reaction enthalpy for the combustion of hydrogen is -286 KJmol^{-1}.
   H$_2$ (g) + 1/2 O$_2$ (g) $\rightarrow$ H$_2$O (l)
   Calculate the standard enthalpy of combustion of propene. (10%)

7. Calculate the work done when 10 g of Cu reacts with hydrochloric acid in (a) a closed vessel of fixed volume (10%), (b) an open beaker at 25 $^{\circ}$C (10%). (Cu + HCl $\rightarrow$ CuCl$_2$ + H$_2$)

8. Please identify the definition of 1 cal (calories), 1 J (joule), and 1 eV (electronvolt). (20%)