一、Find the $\Delta S_{\text{sur}}$, (the surrounding) and $\Delta S_{\text{univ}}$ (the universe) if 2.000mol of super cooled liquid water at $-15.00^\circ \text{C}$ freezes irreversibly at constant pressure of 1.000atm ice at $-15.00^\circ \text{C}$. Assume the molar heat capacity of liquid water to be constant and equal to 76.1JK$^{-1}$mol$^{-1}$, and that of ice to be constant and equal to 37.15JK$^{-1}$mol$^{-1}$, and the surrounding remain at equilibrium at $-15.00^\circ \text{C}$. The latent heat of fusion of water is 333.5 Jg$^{-1}$. (15%)

二、The Half-life of 235U is equal to 7.1x$10^8$ years (10%)
   a. Find the rate constant.
   b. Find the time required to a sample of 235U to decay to 10.0% of its original amount.

三、(a) Calculate the work done on a closed system consisting of 50.00 g of argon, assumed ideal, when it expands reversibly from a volume of 5.000 L to a volume of 10.00 L at a constant temperature of 298.15 K. (5%)
   (b) A system consisting of 2.00 mole of argon, assumed ideal with $C_v$ equal to $3nR/2$, expands adiabatically and reversibly from a volume of 5.00 L and a temperature of 373.15 K to a volume of 20.00 L. Find the final temperature and the work. (8%)

四、(a) Write the cell symbol, the cell reaction equation, and the Nernst equation for the cell with the half-reactions
   
   $2\text{Hg}(l) + 2\text{Cl}^- \rightarrow \text{Hg}_2\text{Cl}_2(s) + 2\text{e}^-$
   
   $\text{Cl}_2(g) + 2\text{e}^- \rightarrow 2\text{Cl}^-$

   (b) Find the potential difference of the cell at 298.15 K if P (Cl$_2$) = 0.950 atm and a(Cl$^-$) = 0.500, $E^0 = 1.091$ V. (10%)

五、Find the boiling elevation constant for water and the boiling temperature at 1.00 atm of a solution of sucrose with 10.00 g of sucrose in 1.000kg of water. The molar enthalpy change of vaporization is 40.67KJmol$^{-1}$ (sucrose,$C_{12}H_{22}O_{11}$, 342.3 g/mol). (12%)
六、Use the cycle rule to show the this equation
\[
\left( \frac{\partial H}{\partial P} \right)_{T,n} = -C_P \mu_{J,T}, \text{where}
\]
\[
\mu_{J,T} = \left( \frac{\partial T}{\partial P} \right)_{H,n}
\]
is the Joule-Thomson coefficient. (12%)

七、(a) Show that \[
\left( \frac{\partial U}{\partial V} \right)_{T,n} = 0
\]
for an ideal gas, using only the thermodynamic equation of state
\[
P V = n R T
\]
and the fact that \[
\left( \frac{\partial U}{\partial V} \right)_{T,n}
\]
is zero.

八、Show that the following scheme proposed by R. Ogg, *J. Chem. Phys.*, 15, 337 (1947) is consistent with, and can explain, the observed first-order decomposition of \(N_2O_5\), (15%)

\[
\begin{align*}
N_2O_5 & \rightleftharpoons NO_2 + NO_3 \quad (1) \\
NO_2 + NO_3 & \stackrel{k_1}{\longrightarrow} NO + O_2 + NO_2 \quad (2) \\
NO + NO_3 & \stackrel{k_2}{\longrightarrow} 2NO_2 \quad (3)
\end{align*}
\]