Problem #1
The vapor pressure of solid NaF varies with temperature as

$$\ln P_{\text{atm}} = -\frac{34,450}{T} - 2.01\ln T + 33.74$$

and the vapor pressure of liquid NaF varies with temperature as

$$\ln P_{\text{atm}} = -\frac{31,090}{T} - 2.52\ln T + 34.66$$

Calculate:

(a) The normal boiling temperature of NaF.  
(b) The temperature and pressure at the triple point.  
(c) The molar heat of evaporation of NaF at its normal boiling temperature.  
(d) The molar heat of melting of NaF at the triple point.  
(e) The difference between the constant-pressure molar heat capacities of liquid and solid NaF.

Problem #2
The initial state of quantity of monatomic ideal gas is $P = 1$ atm, $V = 1$ liter, and $T = 373^\circ\text{K}$. The gas is subjected to the changes of state as follows:

(1) isothermally expanded to a volume of 2 liters, and
(2) cooled at constant pressure to volume $V$, and
(3) adiabatically compressed to return to its initial state.

All of the changes of state are conducted reversibly. Calculate the value $V$ and the total work done on or by the gas.
**Problem #3**

One mole of a monatomic deal gas is subjected to the following sequence of steps:

(a) Starting at 25°C and 10 atm, the gas expands freely into a vacuum to triple its
volume;

(b) The gas is next heated reversibly to 125°C at constant volume;

(c) The gas is reversibly expanded at constant temperature until its volume is again
tripled;

(d) The gas is finally reversibly cooled to 25°C at constant pressure.

Calculate the values of $q$ and $W$ in the changes in $1 \rightarrow 2$, $2 \rightarrow 3$, $3 \rightarrow 4$, $4 \rightarrow 5$ processes.  

(15%)  

\[ P \quad 1 \quad 3 \quad a \quad b \quad 2 \quad c \quad d \quad 5 \quad V \]

**Problem #4**

Define (a) the ideal solution and (b) the regular solution.  

(10%)  

**Problem #5**

The activity coefficient of Zn in liquid Cd-Zn alloys at 435°C can be represented by

\[
\log y_{\text{Zn}} = 0.38 X_{\text{Zn}}^2 - 0.13 X_{\text{Cd}}^2.
\]

Calculate the corresponding expression for the composition dependence on $\log y_{\text{Cd}}$, and hence calculate the activity of Cd, $a_{\text{Cd}}$, in the $X_{\text{Cd}} = 0.5$ alloy at 435°C. ($X_i$ is the mole fraction of the species $i$.)  

(15%)
Problem #6

The following equilibrium data have been determined for the reaction: 

\[ \text{NiO} + \text{CO} \rightarrow \text{Ni} + \text{CO}_2 \]

<table>
<thead>
<tr>
<th>( T(\degree C) )</th>
<th>( K \times 10^{15} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>663</td>
<td>4.535</td>
</tr>
<tr>
<td>716</td>
<td>3.323</td>
</tr>
<tr>
<td>754</td>
<td>2.554</td>
</tr>
<tr>
<td>793</td>
<td>2.037</td>
</tr>
<tr>
<td>852</td>
<td>1.577</td>
</tr>
</tbody>
</table>

(a) Plot the data using appropriate axes and find \( \Delta H^\circ \) and \( \Delta G^\circ \) at 1000\degree K.

(b) Will an atmosphere of 15% CO, 5% CO and 80% N\(_2\) oxidize nickel at 1000\degree K?

Problem #7

The electrochemical cell consists of two electrodes. One is a solid FeO/Fe mixture. The other is a gaseous O\(_2\) electrode. The porous platinum coating acts only as a catalyst. The electrolyte is a ZrO\(_2\)/Y\(_2\)O\(_3\) solid solution that conducts oxygen ion (O\(^{2-}\)) between oxygen side and FeO/Fe side.

\[ \text{Fe} + \frac{1}{2} \text{O}_{2\text{e}} \rightarrow \text{FeO} \quad \Delta G^\circ \text{(in Joules)} = -244,550 + 98.5T \]

(a) Write the half-cell reactions for the cathode and the anode.

(b) What is the open circuit voltage at 1000\degree K when the oxygen pressure on the oxygen electrode side is one atmosphere?