PROBLEM 1

Gray tin and white tin (atomic mass 118.7 g/mol) have densities of 575 and 728 kg/m$^3$, respectively.

Calculate the work done by the system on the surroundings when white tin transforms to gray tin at 286 K and 1 atm pressure. The answer should be in J/mol.

1 atm = $10^5$ N/m$^2$ = 0.1 MPa. 1 cal = 4.19 J.

PROBLEM 2

Given a liquid phase which has a surface tension of 0.5 J/m$^2$, calculate the work done by the system when a mole of liquid is converted from the form of spheres 0.1 mm in diameter to a thin foil of thickness 1 µm.

PROBLEM 3

Suppose the liquid of the previous problem has density 1,000 kg m$^{-3}$, a molecular weight of 102 g/mol, and a heat capacity $C_p = 29$ J mol$^{-1}$ K$^{-1}$, and that the process is performed adiabatically. Calculate the temperature change in the system.

PROBLEM 4

Consider the differential $dZ = pdV - Vdp$.

(a) Is this an exact differential?
(b) Find an integrating factor, i.e. a function $\lambda(p, V)$ such that the differential $\lambda dZ$ will be exact.

PROBLEM 5

(a) How much work is done when 1 liter of ideal gas at 25 ºC is reversibly and isothermally compressed from 1 atm to 2 atm? The answer should be in cal or J. Is this work done by or on the gas?
(b) If the gas of part (a) is enclosed in a jacket containing 1 kg of water, by how much would the temperature of the water change? Neglect the heat capacity of the gas.
(c) If the ideal gas is surrounded by an adiabatic jacket, i.e. the compression is adiabatic rather than isothermal, how much work is performed by the system and what is the final temperature of the gas. Here you may take $C_p = 40$ J mol$^{-1}$ K$^{-1}$. 
PROBLEM 6

Iron undergoes transformations at 1033 K (ferromagnetic $\alpha \rightarrow$ paramagnetic $\alpha$), 1183 K ($\alpha \rightarrow \gamma$), 1673 K ($\gamma \rightarrow \delta$), and 1809 K ($\delta \rightarrow$ liquid).

The respective heats of transformation are 1.2, 0.22, 0.21, and 3.3 kcal/mol.

The heat capacity of iron is

$$C_p = a + b \times 10^{-3} T$$

where

<table>
<thead>
<tr>
<th></th>
<th>$\alpha$ (T&lt;1033 K)</th>
<th>$\alpha$ (T&gt;1033 K)</th>
<th>$\gamma$</th>
<th>$\delta$</th>
<th>Liquid</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a$, cal mol$^{-1}$ K$^{-1}$</td>
<td>4.18</td>
<td>9.0</td>
<td>1.84</td>
<td>10.5</td>
<td>10.0</td>
</tr>
<tr>
<td>$b$, cal mol$^{-1}$ K$^{-2}$</td>
<td>5.92</td>
<td>--</td>
<td>4.66</td>
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</tbody>
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Determine $H_{1923} - H_{298}$ for iron using these data.

PROBLEM 7

Calculate the entropy change in the system, in the surroundings, and the total entropy change when 100 g of Pb (atomic mass 207 g/mol) solidifies at 20 K below the equilibrium melting temperature of 600 K.

The heat of melting is 1,150 cal/mol, and the heat capacities of the solid and liquid are 7.03 and 7.31 cal mol$^{-1}$ K$^{-1}$ at the melting point, respectively.

PROBLEM 8

Use the data given to calculate $\Delta U_{298}^0$, $\Delta H_{298}^0$, $\Delta S_{298}^0$, for the following reactions

(a) $C + O_2 \rightarrow CO_2$
(b) $2Al + (3/2) O_2 \rightarrow Al_2O_3$
(c) $2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3$

<table>
<thead>
<tr>
<th></th>
<th>Heat of formation $\Delta H_{298}^0$, cal/mol</th>
<th>Entropy of formation $S_{298}^0$, cal mol$^{-1}$ K$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>-</td>
<td>6.77</td>
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<tr>
<td>Al$_2$O$_3$</td>
<td>-400,000</td>
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<tr>
<td>C</td>
<td>-</td>
<td>1.361</td>
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<tr>
<td>CO$_2$</td>
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<tr>
<td>Fe</td>
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<tr>
<td>Fe$_2$O$_3$</td>
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<tr>
<td>O$_2$</td>
<td>-</td>
<td>49.0</td>
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</tbody>
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