If you use Excel or other software for calculations, please do not provide those files, rather paste the results into a Word or pdf file. Please submit only a single file. For electronic submissions put your name in the file name and do not use symbols. If pdf please make sure enlargement is approximately 100%.

Questions

1. A Redlich-Kister expansion describes the excess free energy of mixing of Al-Pb liquids which have a miscibility gap at lower temperatures. The parameters of the expansion are given in the table below where the temperature dependence is $A_l + B_l T$ and with the expansion as can be seen from the table extending from zeroth through second order.

   a. Quantitatively plot the dependence of the total mixing energy on composition at 1500K.
   b. From the plot determine the composition of the two liquids at that temperature.

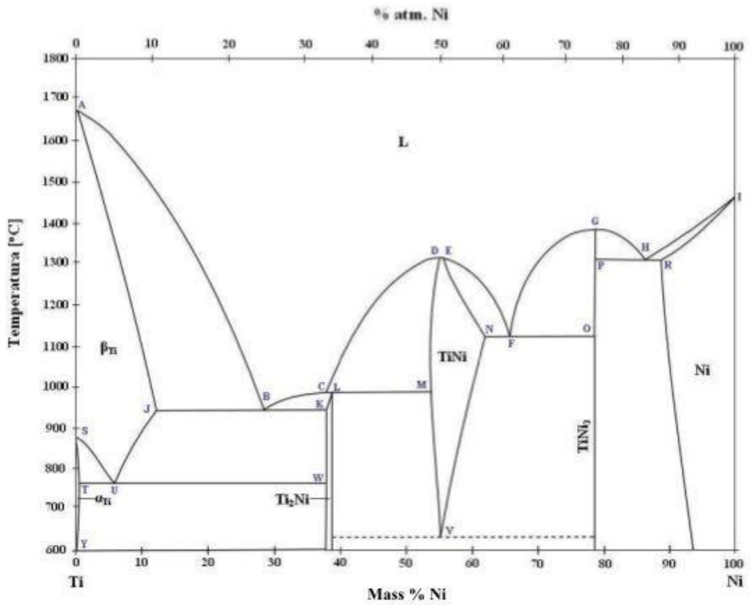
l	A_l(J mol^{-1})	B_l(J mol^{-1} K^{-1})
0	47933.6	−10.71995
1	14407.33	−6.65287
2	4742.36	−0.72034

2. On the Ti-Ni phase diagram in this exam:
   a. Identify the eutectic points (list temperature-composition values or indicate on diagram).
   b. Similarly identify eutectoid points.
   c. Using a tie line, at 900°C determine the proportion of β-Ti and Ti_2Ni phase for an overall composition of 20 mass% Ni.

3. For the Ti-Ni phase diagram sketch a qualitative free energy plot at 1050°C representing the phases and showing the common tangents that delineate the phase regions. Be sure to label the phases and single and two phase regions on the free energy plot. (Make the plot large - fill a page - and draw it carefully so it can be read and I can maximize your credit.)

4. For the Ti-O system
   a. Plot the 298 K free energy of formation for all the stoichiometric phases listed in Appendix E of the text as a function of atomic percent oxygen.
   b. Draw a Richardson-Ellingham diagram for the Ti-O phases starting, of course, with oxidizing the metal to the lowest oxide.

5. From the Richardson-Ellingham diagram provided in this exam determine:
   a. The oxygen potential at which silicon oxidizes to silica at 800°C
   b. The oxygen pressure at that point derived from the diagram.
   c. The H_2/H_2O and CO/CO_2 partial pressure ratios at that point from the diagram
   d. From the diagram identify a metal that will reduce silica (SiO_2) to silicon and write the reaction.


% atm. Ni
Temperatura [°C]
Mass % Ni
Ti
Ni
L
βTi
αTi
Ti2Ni
TiNi
TiNi3
Ni
A
B
C
D
E
F
G
H
I
J
K
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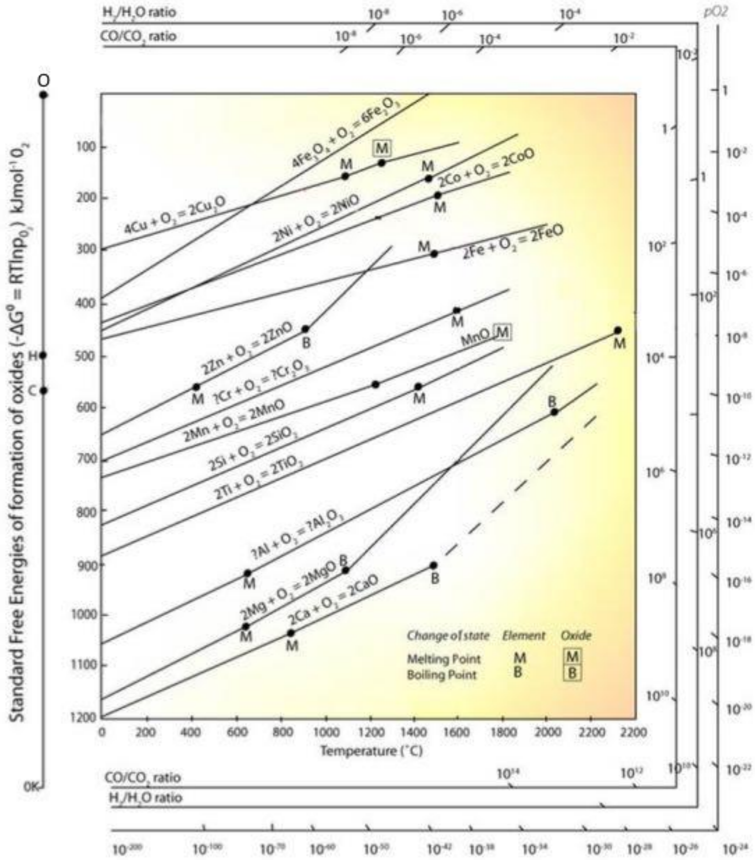

H_2/H_2O ratio
CO/CO_2 ratio
pO2
Standard Free Energies of formation of oxides ($-\Delta G^0 = RT\ln p_{O_2}$) kJmol^{-1} O_2
$4Fe_3O_4 + O_2 = 6Fe_2O_3$
$4Cu + O_2 = 2Cu_2O$
$2Ni + O_2 = 2NiO$
$2Co + O_2 = 2CoO$
$2Fe + O_2 = 2FeO$
$2Zn + O_2 = 2ZnO$
$?Cr + O_2 = ?Cr_2O_3$
$2Mn + O_2 = 2MnO$
MnO
$2Si + O_2 = 2SiO_2$
$2Ti + O_2 = 2TiO_2$
$?Al + O_2 = ?Al_2O_3$
$2Mg + O_2 = 2MgO$
$2Ca + O_2 = 2CaO$
Change of state
Element
Oxide
Melting Point
Boiling Point
Temperature (˚C)
0K