ÉCOLE POLYTECHNIQUE

Département de génie chimique

Programme de métallurgie

MET 6208

ÉNERGÉTIQUE DES SOLUTION

CONTROLE I

Mercredi, le 15 octobre, 2014

10:30 – 13:30

NOTES:
- *All documentation permitted (open book exam)*
- *There are 7 questions and 4figures*

Le professeur: Arthur D. Pelton

Question 1 (3 points)

A homogeneous liquid solution at 1000°C contains 0.500 mol Mg and 0.500 mole Al. The volume of the solution is 0.0137728 litres.
When 0.01 mol of pure Mg is added to the solution the volume increases to 0.0139341 litres. A further addition of 0.01 mol of pure Al is made. What is the final volume of the solution?

Question 2 (3 points)

In the P-T phase diagram of Fe, is the slope dP/dT of the univariant line between the phase fields of α (bcc) and γ (fcc) positive or negative? Explain fully. (See Fig. 1).

Question 3 (3 points)

The liquidus projection of a system A-B-C is given in Fig. 2.
The solubilities in all solid phases are negligible. Assuming that there are no solid state transformations between 25°C and the liquidus, sketch the isothermal section of the phase diagram at 25°C.

Question 4 (3 points)

Isothermal sections of the phase diagram of a system A-B-C at 800°, 700°and 600°C are shown in Fig. 3. All phases are solid and stoichiometric.

(a) What is the invariant reaction which occurs when the system is cooled at equilibrium from 800° to 700°C ?
(b) What is the invariant reaction which occurs when the system is cooled at equilibrium from 700° to 600°C ?

Question 5 (3 points)

The phase diagram of the system Cu-Pb is shown in Fig. 4. At the temperature of the monotectic (983°C), calculate the activity of Cu, with respect to pure liquid Cu as standard state, in the liquid phase at point A and at point B. Assume that Raoult's Law and Henry's Law apply to the solid Cu-rich phase.

Data: Enthalpy of fusion of Cu = 13128 J/mol.

Question 6 (2 points)

A student is optimizing a binary system A-B. The student at first assumes a strictly regular solution expression for the liquid phase (enthalpy of mixing a parabolic function of composition and zero excess entropy), but the fit to the phase diagram is not satisfactory.
He then finds that he can get a good fit if he assumes that the solution is regular, but not strictly regular; that is that the excess entropy is also given by a parabolic function of composition. The excess entropy required is, however, quite large and the student remembers that his professor cautioned him against assuming large excess entropies. He then tries a third approach in which he keeps the excess entropy at zero, but introduces a temperature dependence into the enthalpy of mixing as follows:

$$\Delta h = X_A X_B (a + bT)$$

where *a* and *b* are constants. The fit is now excellent and the student proudly shows his optimization to his professor.

Why is the professor not pleased ?

Question 7 (3 points)

A phase diagram section of the system Fe-Cr-S-O is proposed. The y-axis is log P_{SO2} where P_{SO2} is the equilibrium pressure of SO_2. The x-axis is the molar metal ratio n_{Cr}/n_{Fe}. The diagram is drawn at constant temperature, constant equilibrium oxygen pressure P_{O2} and constant total hydrostatic pressure.
Is this guaranteed to be a "true" phase diagram section, single-valued at every point ?
Explain fully.

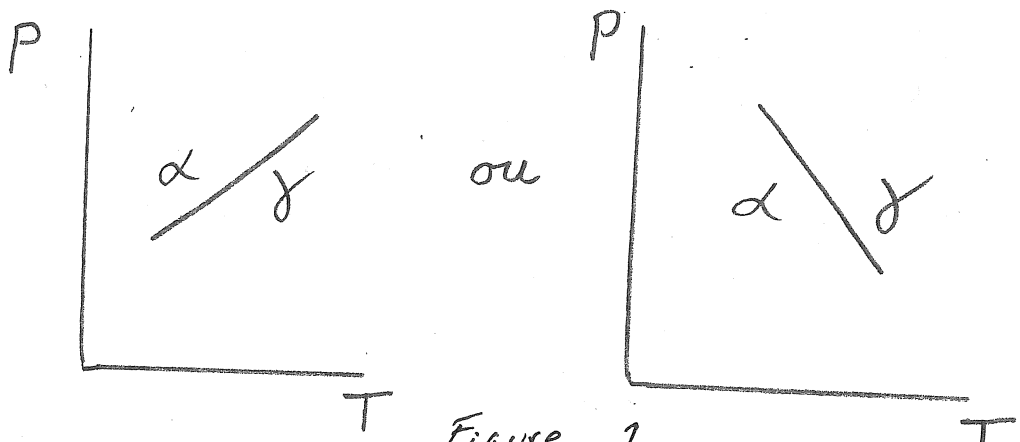

Figure 1

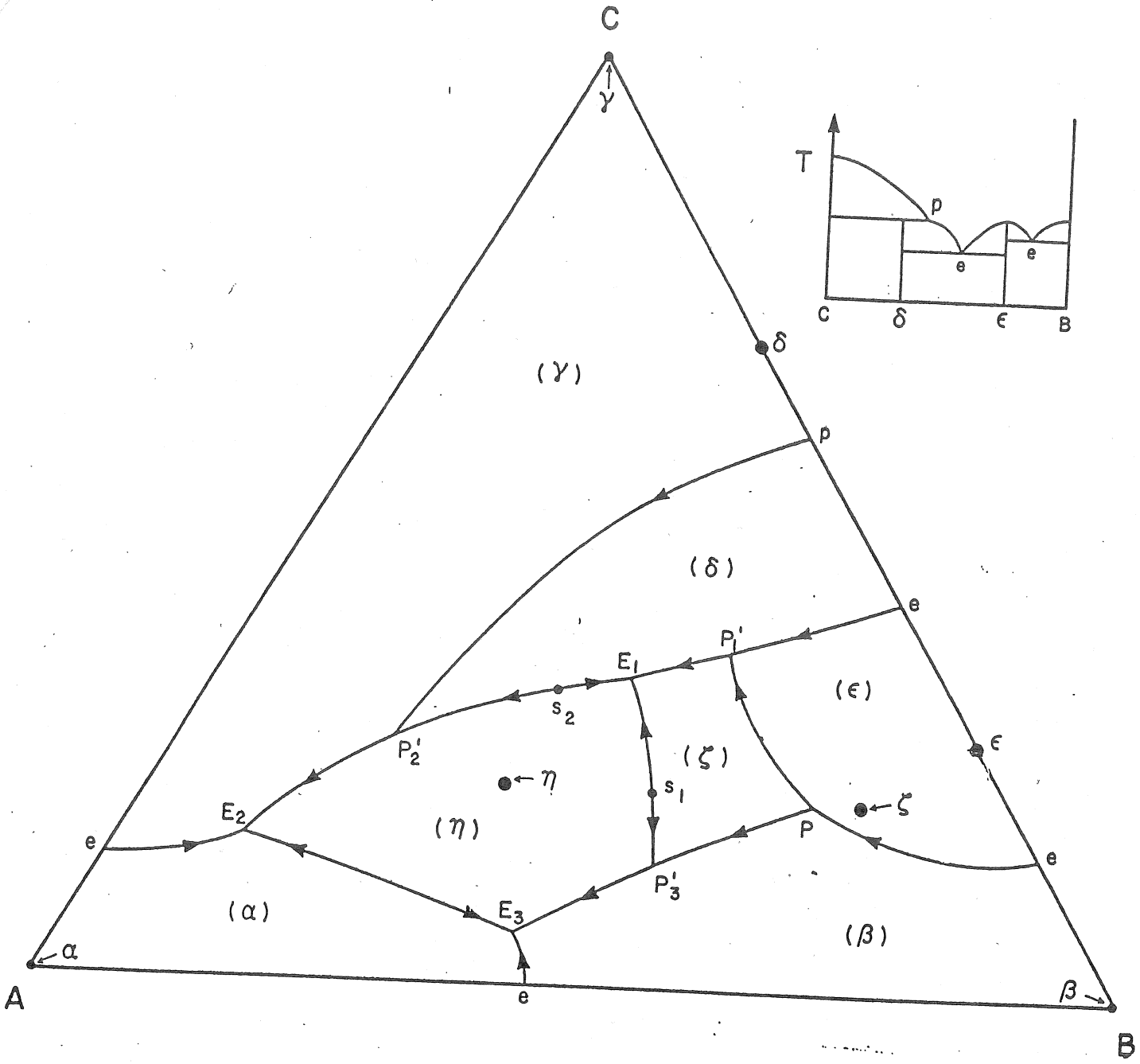

Figure 2

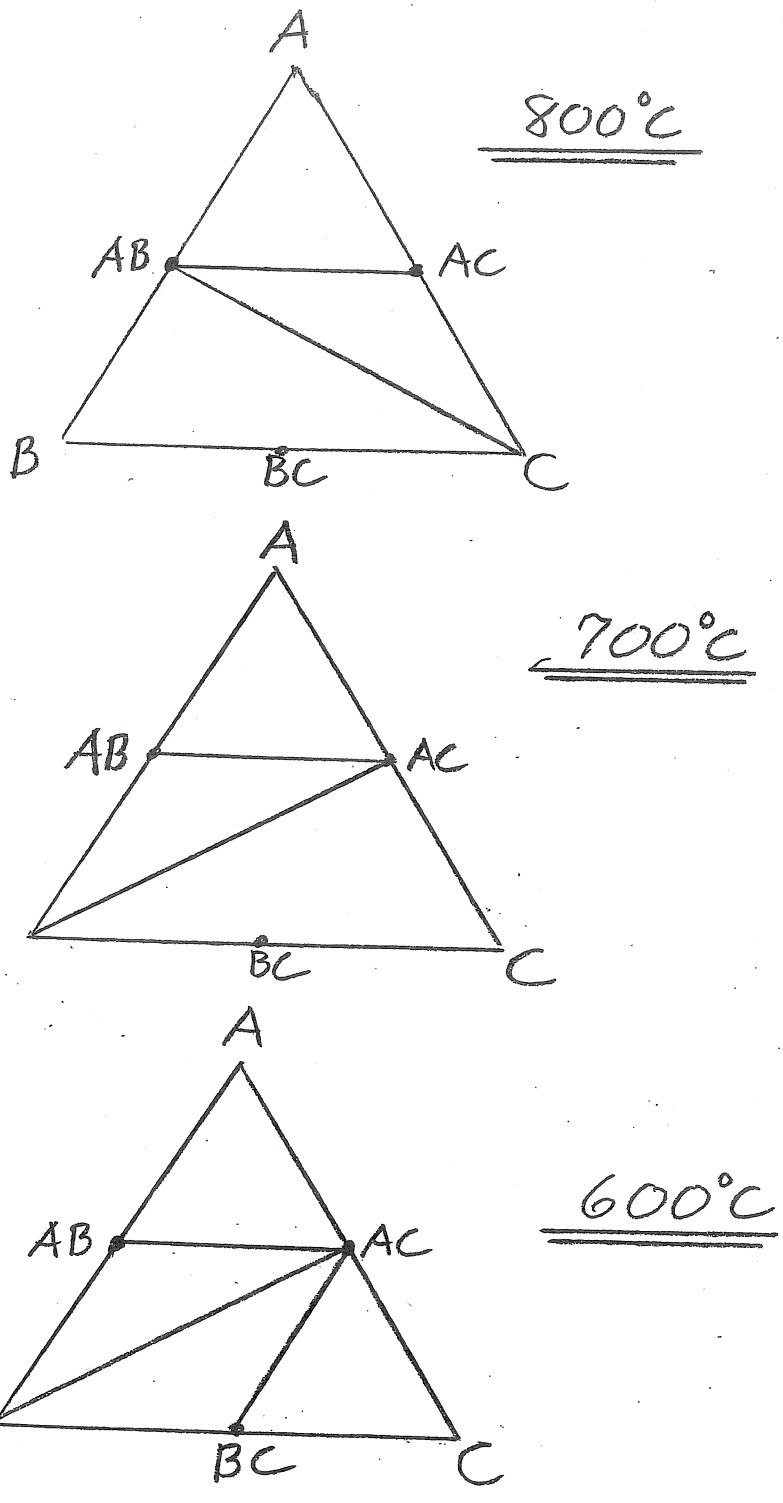

Figure 3

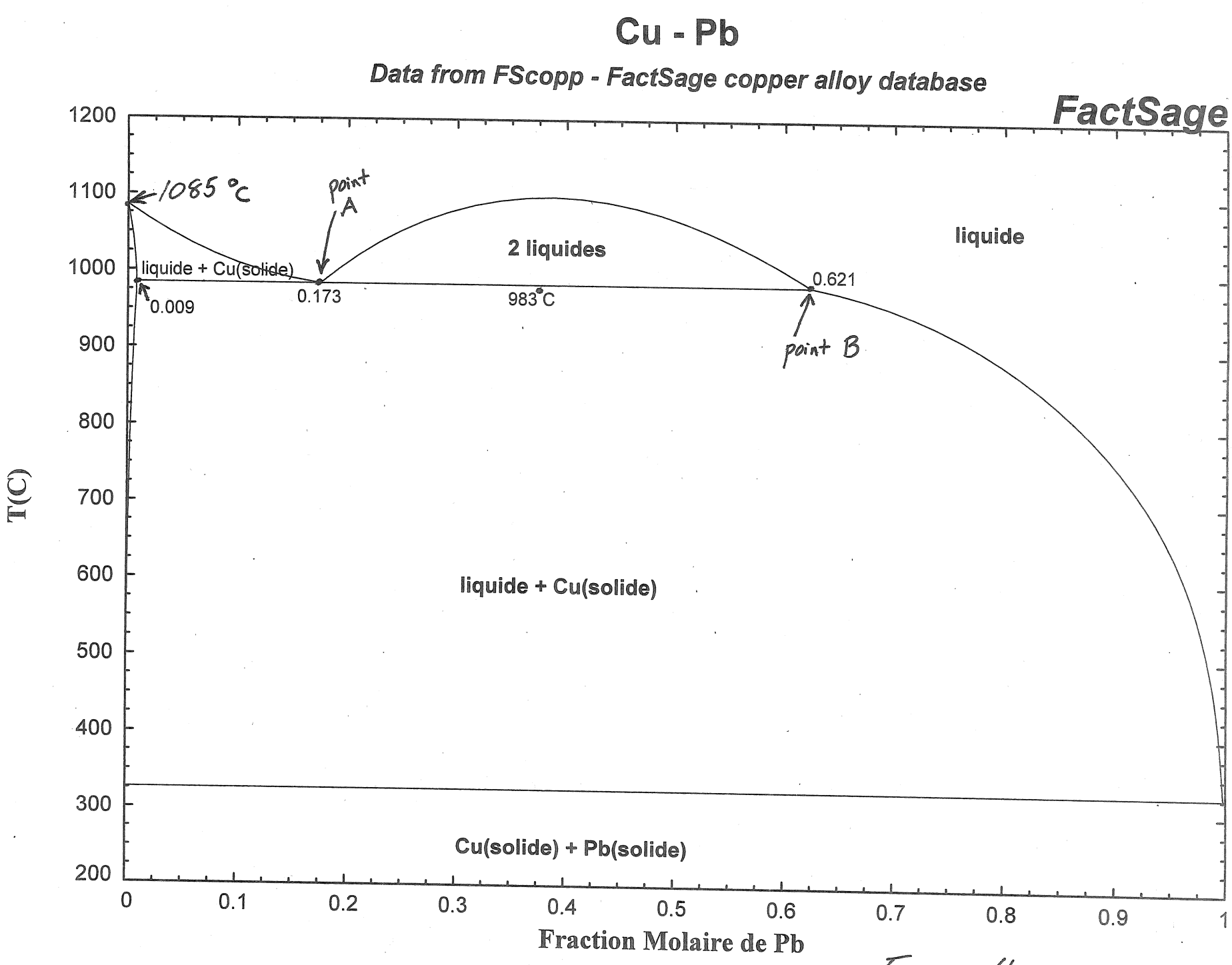
Cu - Pb
Data from FScopp - FactSage copper alloy database
FactSage
1200
1100
1000
900
800
700
600
500
400
300
200
T(C)
1085 °C
point A
2 liquides
liquide
liquide + Cu(solide)
0.009
0.173
983°C
0.621
point B
liquide + Cu(solide)
Cu(solide) + Pb(solide)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Fraction Molaire de Pb

Figure 4