UNIVERSITY OF OSLO

Faculty of mathematics and natural science

Exam in: MEF 3000 / MEF 4000
Examination date: 1.7.05
Examination time: 9:00-12:00 (3 hours)

The problem set is on 3 pages. The appendixes are: 2 copies each of three grids/templates, that may be used in the tasks: 1b. 2 copies of the phase diagram for tasks 2a-b.

Allowed aids: Calculator.

Control that the task set is complete before answering the problems!

Task 1: (33 %)

For the structure Platinum Chloride ($PtCl_2$), the following information is given:

Spacegroup: *Pnmn*
Unit cell dimensions: a = 3.86 Å, b = 3.35 Å, c = 11.05 Å.
Pt in 2(b) position (0, 0.5, 0)
Cl in 4(e) position (0.173, 0, 0.132)

In the International Tables of Crystallography we find the following positions generated from a general position:

(1) x, y, z
(2) 0.5-x, 0.5-y, 0.5+z
(3) 0.5+x, 0.5-y, 0.5-z
(4) -x, y, -z
(5) -x, -y, -z
(6) 0.5+x, 0.5+y, 0.5-z
(7) 0.5-x, 0.5+y, 0.5+z
(8) x, -y, z

a) What type of Bravais lattice, and what crystal system is this?

How many formula units are there in the cell?

Give the corresponding point group symbol for this space group.

b) Draw the structure as a projection on the bc plane. Feel free to use the appended grid, but remember to hand it in with the answer.
Hint: Draw at least two unit cells in the b-direction.

c) What is the distance between Pt and Cl?

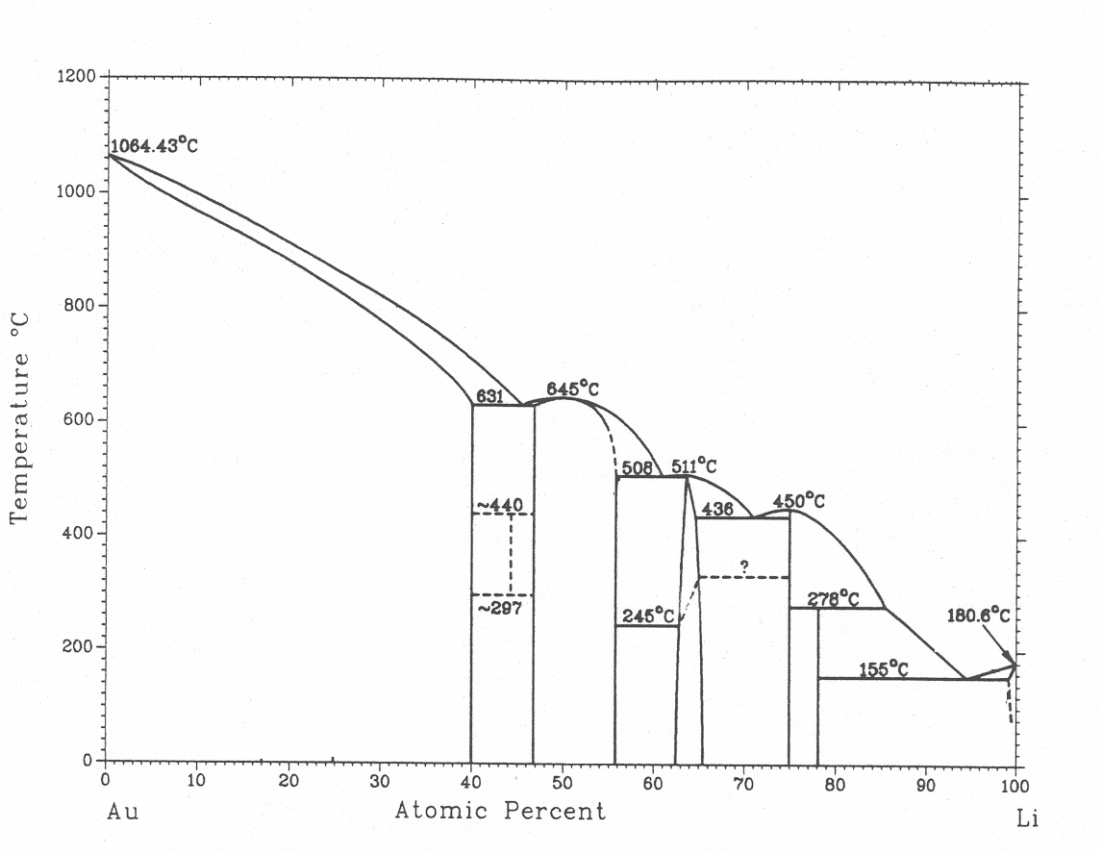
d) What is the coordination environment for Pt?

Can you give an explanation why Pt has adopted this geometry?

e) What types of connections are there between the polyhedra?

Task 2: (33 %)

Given the phase diagram below for the Au-Li system:
(Feel free to fill and mark on one of the appended copies)



a) - Name the phases and note which phases are in equilibrium in the different areas.
- Mark all the areas where a singular phase is occurring by a different color/shading. Please use one of the appended enlarged copies and remember to hand it in with the answers.

b) - Mark all the invariant points with numbers on the appended phase diagram and hand it in with the answers,
- give a list of the numbers with the name of the different types of invariant reactions,
- and give **one** example for each different type of invariant reaction that takes place by giving the reaction using the named phases in a).

c) Assume that you have a sample with overall composition 80 at% Li at 800 °C. Describe what happens with the sample during cooling down to room temperature.

d) Give the requirements for good solid solubility between two phases.

Comment on the extent of the area between 0 and 40 at% Li in this respect. What type of solid solubility is this an example of?

Task 3: (34 %)

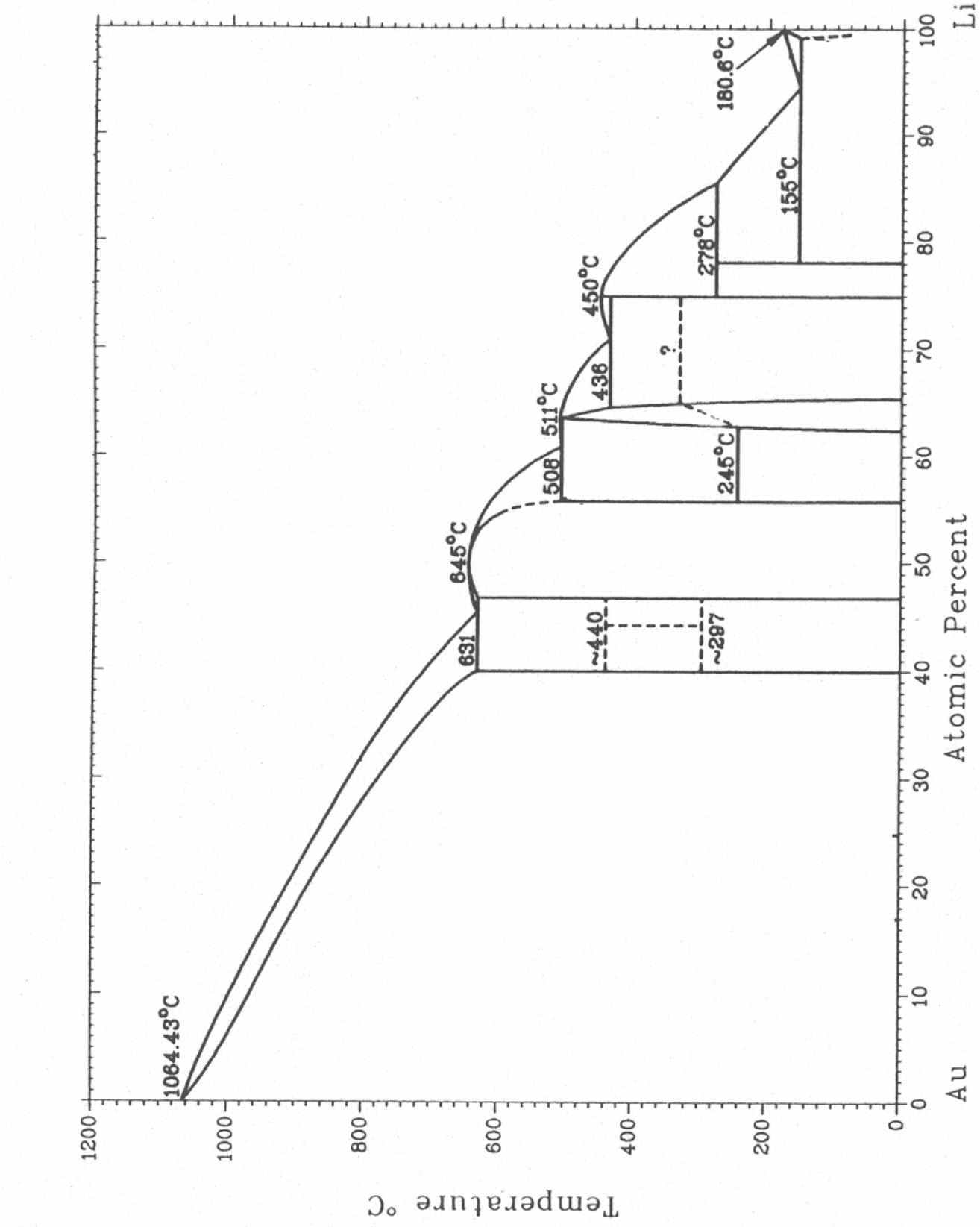
a) Describe the overall crystal structure features of $YBa_2Cu_3O_7$. Discuss the superconductivity in $YBa_2Cu_3O_\delta$ related to atomic valencies and oxygen content. What is the differences between type I and type II superconductors?

b) Describe the characteristic features for semi-conductors? Si is an extrinsic semiconductor when doped with a group III and group IV element. Describe these two types of doping.

c) The electrical properties of ionic solids are controlled by crystal defects. Explain vacancy, interstitial and solid electrolyte ionic conduction. Use NaCl, AgI and β-alumina, respectively, as examples.

d) Describe the main features of pyroelectricity and piezoelectricity?

e) What is diamagnetism? Describe the Curie and Curie-Weiss law for paramagnetic, ferromagnetic and anti-ferromagnetic materials. Show $1/\chi$ (χ is inverse magnetic susceptibility) as a function of temperature for paramagnetic, ferromagnetic and anti-ferrromagnetic materials. Explain the differences.


Temperature °C
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Au
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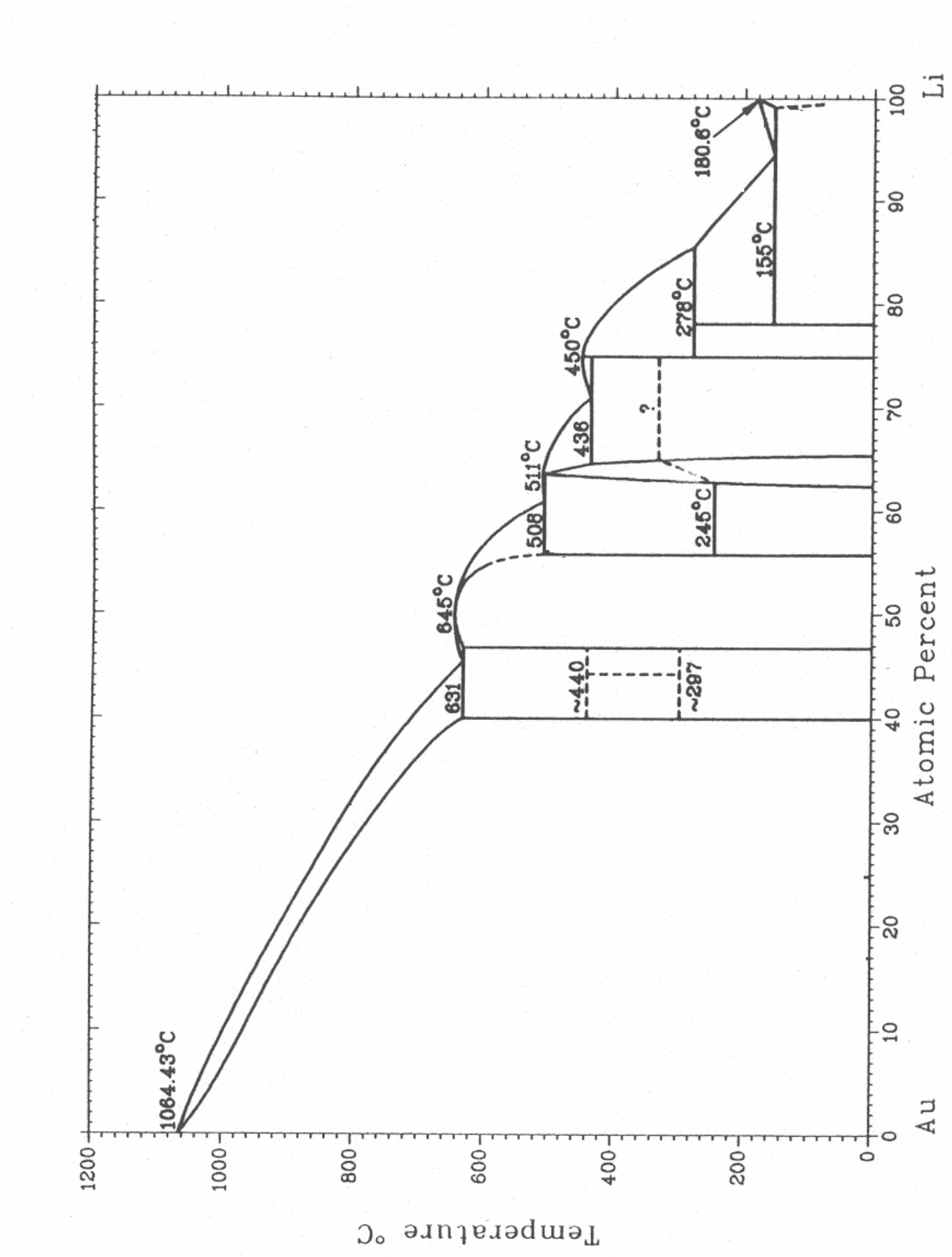
30
40
50
60
70
80
90
100
Li
Atomic Percent
1064.43°C
631
645°C
~440
~297
508
511°C
438
?
450°C
278°C
245°C
180.6°C
155°C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