**EXAM "Materiaalkunde- BaSc Applied Physics 2nd YEAR"**

**MONDAY APRIL 16th 2012**
**Time: 9.00-12.00 h**
**MK VIP room 13.045**

***Please mention your name + student number on each page, insert page numbers and write on first page the total # of pages submitted.***

## -1- Mechanical properties –Metals (2pt)

(a) Define: Burgers vector; slip system in BCC

(b) Determine the magnitude of the Schmid factor for an FCC single crystal oriented with its [120] direction parallel to the loading axis.

(c) Is a nanocrystalline material stronger or weaker than a material with large grain-size ? Give a brief explanation.

## -2- Crystal Structure of Non-Metals (2 pt)

(a) Compute the theoretical density of diamond given that the C—C distance and bond angle are 0.154 (nm) and 109.5°, respectively. ($A_C$=12.01 (g/mol), $N_A = 6.023\ 10^{23}$ atoms/mol)

(b) Compute the atomic packing factor for the diamond cubic crystal structure. Assume that bonding atoms touch one another, that the angle between adjacent bonds is 109.5°, and that each atom internal to the unit cell is positioned a/4 of the distance away from the two nearest cell faces (a is the unit cell edge length).

(c) How would you measure the vacancy concentration and dislocation density in diamond? Give a brief explanation.

## -3- Phases and Phase diagrams and design (3 pt)

(a) For an alloy of composition 52 wt% Zn-48 wt% Cu, cite the phases present and their mass fractions at the following temperatures: 1000°C, 800°C, 500°C, and 300°C. (Fig.3.1)

(b) Design: Is it possible to have an iron–carbon alloy for which the mass fractions of total cementite and proeutectoid ferrite are 0.057 and 0.36, respectively? Why or why not? (Fig.3.2 and Fig. 3.3.)

(c) Design: Is it possible to have an iron–carbon alloy for which the mass fractions of total ferrite and pearlite are 0.860 and 0.969, respectively? Why or why not? (Fig.3.2 and Fig.3.3.)

**p.t.o.**

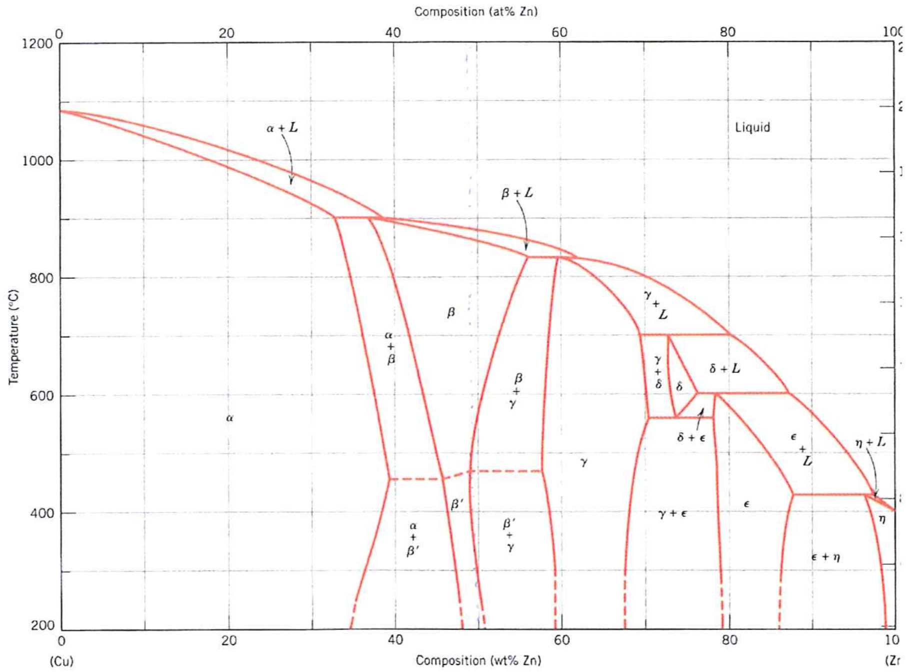


Fig.3.1

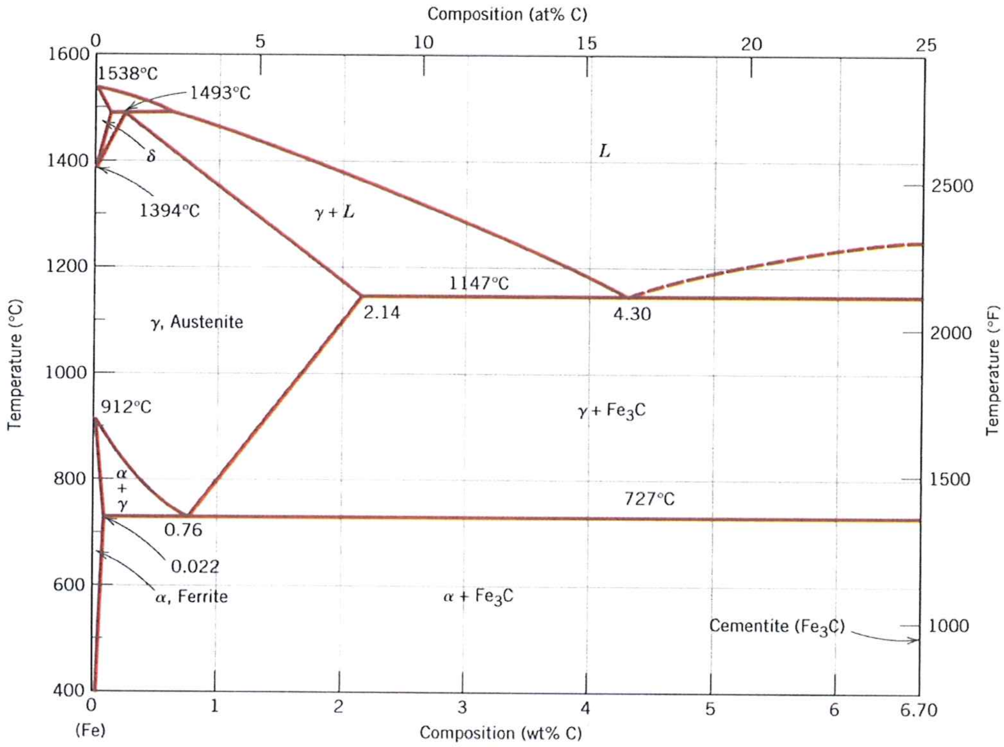


Fig.3.2

**p.t.o.**

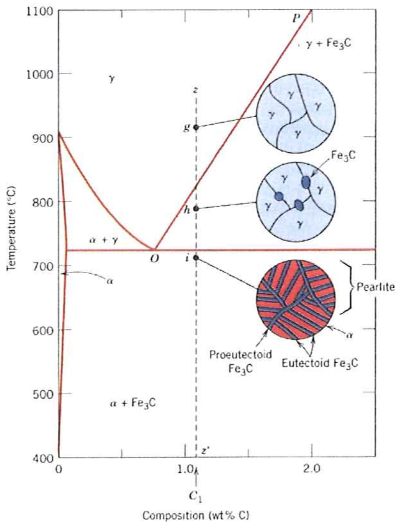


Fig.3.3

## -4- Polymers (1pt)

For a linear polymer molecule, the total chain length $L$ depends on the bond length between chain atoms $d$, the total number of bonds in the molecule N, and the angle between adjacent backbone chain atoms $\theta$, as follows:

$$L = Nd\sin\left(\frac{\theta}{2}\right)$$

Furthermore, the average end-to-end distance for a series of polymer molecules $r$ in is equal to $r = d\sqrt{N}$

A linear polyethylene has a number-average molecular weight of 600,000 (g/mol); Needless to say that each repeat unit has 2 C atoms and 4 H atoms (with 12.01 (g/mol); 1.08 (g/mol) respectively) in polyethylene.

Compute the average values of $L$ and $r$ for this material *(see Q. -2- for the values of d and $\theta$)*

## -5- Functional Materials Properties (1 pt)

(a) At room temperature the electrical conductivity of PbS is 50 $(\Omega/m)^{-1}$, whereas the electron and hole mobilities are 0.06 and 0.02 $m^2/V$-s, respectively. Compute the intrinsic carrier concentration for PbS at room temperature. (e- charge $1.602\ x10^{-19}$ (C) )

(b) An n-type Si-based semiconductor is known to have an electron concentration of $5\ x10^{17}$ $m^{-3}$ at room temperature. If the electron drift velocity is 700 m/s in an electric field of 1000 V/m, calculate the conductivity of this material.

**-6- Terms and Concepts (1 pt)**
Summarize in a concise way the following terms and concepts:

(a) Burgers vector
(b) Griffith's criterion in fracture
(c) Cementite
(d) Ferrimagnetism
(e) Superconductivity
(f) Miller indices
(g) Edge dislocation
(h) Fick's laws in atomic diffusion
(i) Recovery
(j) Eutectoid