CARLETON UNIVERSITY

Department of Civil and Environmental Engineering

Civil Engineering Materials – CIVE 2700

Midterm Examination

February 16, 2006

Instructor: Professor George Hadjisophocleous

Duration: 2 hours

Exam type: Closed book (drafting tools and calculators allowed)

Student Name:_____

Student I.D._____

Instructions:

1. Write all your answers on the examination paper only.
2. Use a dark pencil or a pen and write succinctly, clearly and legibly.
3. If a question has missing information, make an engineering assumption (e.g. assume a reasonable value for a missing parameter) and proceed to answer.
4. This examination question paper **MAY NOT** be taken from the examination room.

Problem	Mark
1	/30
2	/6
3	/6
4	/6
5	/12
6	/12
7	/16
8	/12

Civil Engineering Materials – CIVE 2700 – Midterm Examination, February 16, 2006.

Problem 1. Fill in the blanks. Each correct answer is worth 1%.

1. Name four main groups that materials are classified into:

a)_____, b) _____,

c) _____, d) _____.

2. Name four types of properties of engineering materials:

a)_____, b) _____, c) _____, and d) _____.

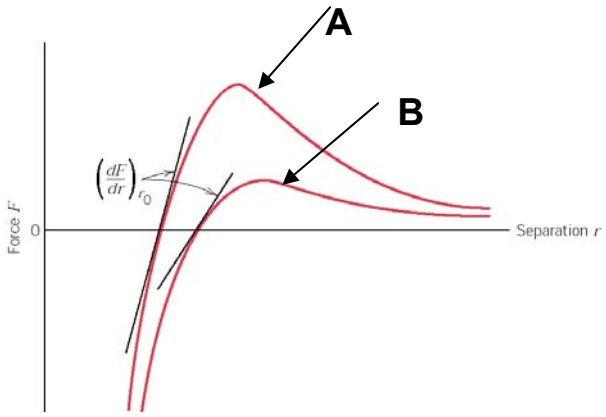
3. Small reversible deformations of materials due to external loading are called _____ deformations.

4. Poisson's ratio is the ratio of _____

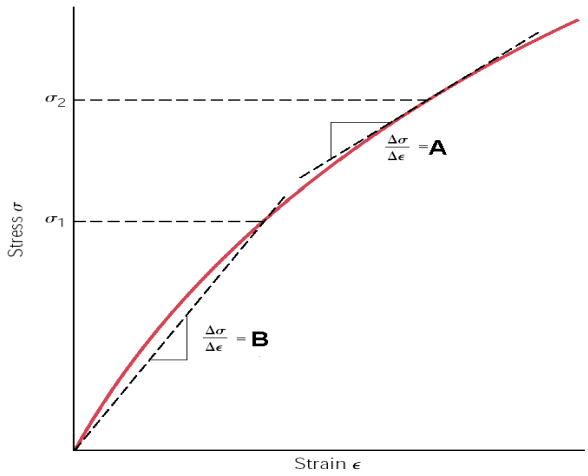
5. _____ is the measure of the degree of plastic deformation that a specimen undergoing a tensile strength tests has been sustained at fracture.

6. _____ is a measure of a materials resistance to localized plastic deformation.

7. The figure below shows a force versus interatomic separation for two materials. The atoms of material _____ are weakly bonded and the atoms of material _____ are strongly bonded.



8 In the figure below A is the _____ and B the _____ _____.



9. _____ is the phenomenon of the existence of more than one crystal structure in the same element or compound. When found in elemental solids the condition is called _____.

10. _____ is a material property that is indicative of the extend to which a material expands upon heating.

11. The property that characterizes a material's ability to transfer heat is the _____.

12. Cubic unit cells with atoms located at each of the corners and the centres of all its cube faces are called _____

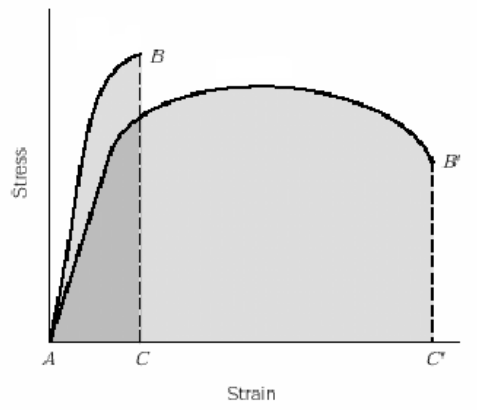
13. The atomic packing factor (APF) is the ratio of the _____ _____.

14. Name two types of point defects in crystals and two types of line defects:

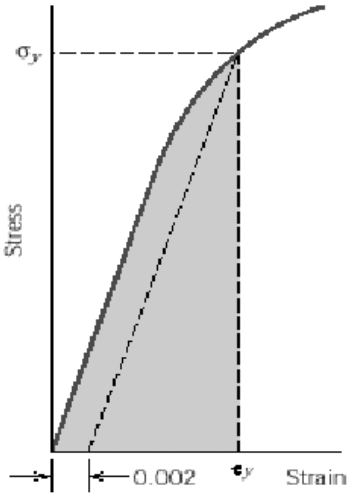
    a. Point defects: a) _____, b) _____

    b. Line defects: a) _____, b) _____

15. In the Figure below material with the curve A-B is a _____ material, while material with A-B' curve is a _____ material. The area under the curves represents the _____.



16. The shaded area in the Figure below is the modulus of _____.

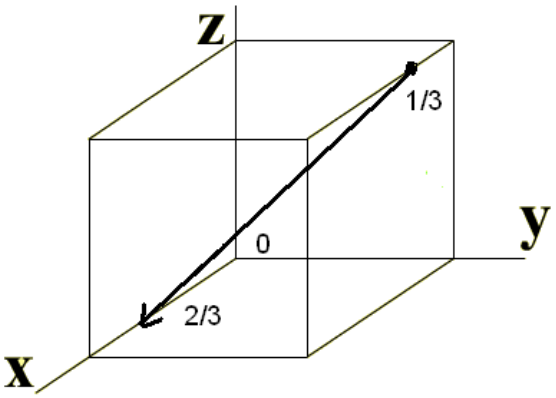


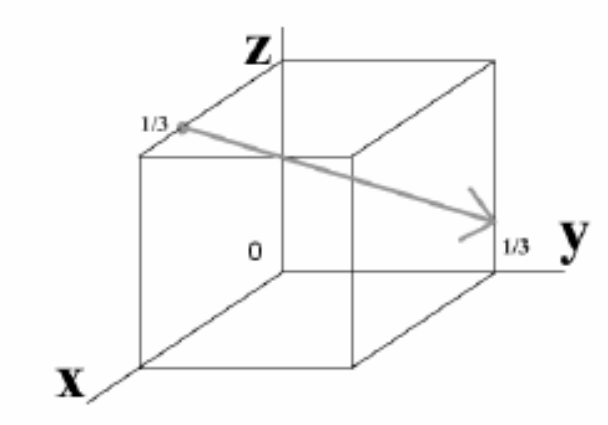
Problem 2. (6%)

Calculate the APF of a BCC unit cell.

Problem 3. (6%)

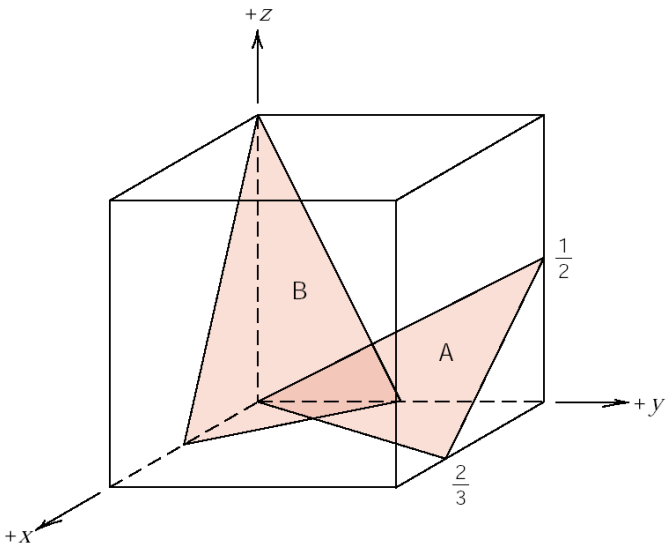
Determine the indices for the directions shown in the following cubic unit cells:





Problem 4. (6%)

Determine the Miller Indices of the two planes shown in the following cubic unit cell.



Problem 5 (12%)

a) Consider the impurity diffusion of gallium into silicon wafer. If gallium is diffused into a silicon wafer with no previous gallium in it at a temperature of 1100°C for 3 h, what is the depth below the surface at which the concentration is 10^{22} atoms/m^3 if the surface concentration is 10^{24} atoms/m^3?($D_{1100°C}$=7.0 x 10^{-17} m^2/s)

Problem 6 (12%)

a) Determine the number of vacancies (vacancies/cm^3) needed for BCC iron crystal to have a density of 7.87 g/cm^3. The lattice parameter of the iron is 2.866×10^{-8} cm. The atomic mass of iron is 55.847 g/mol.

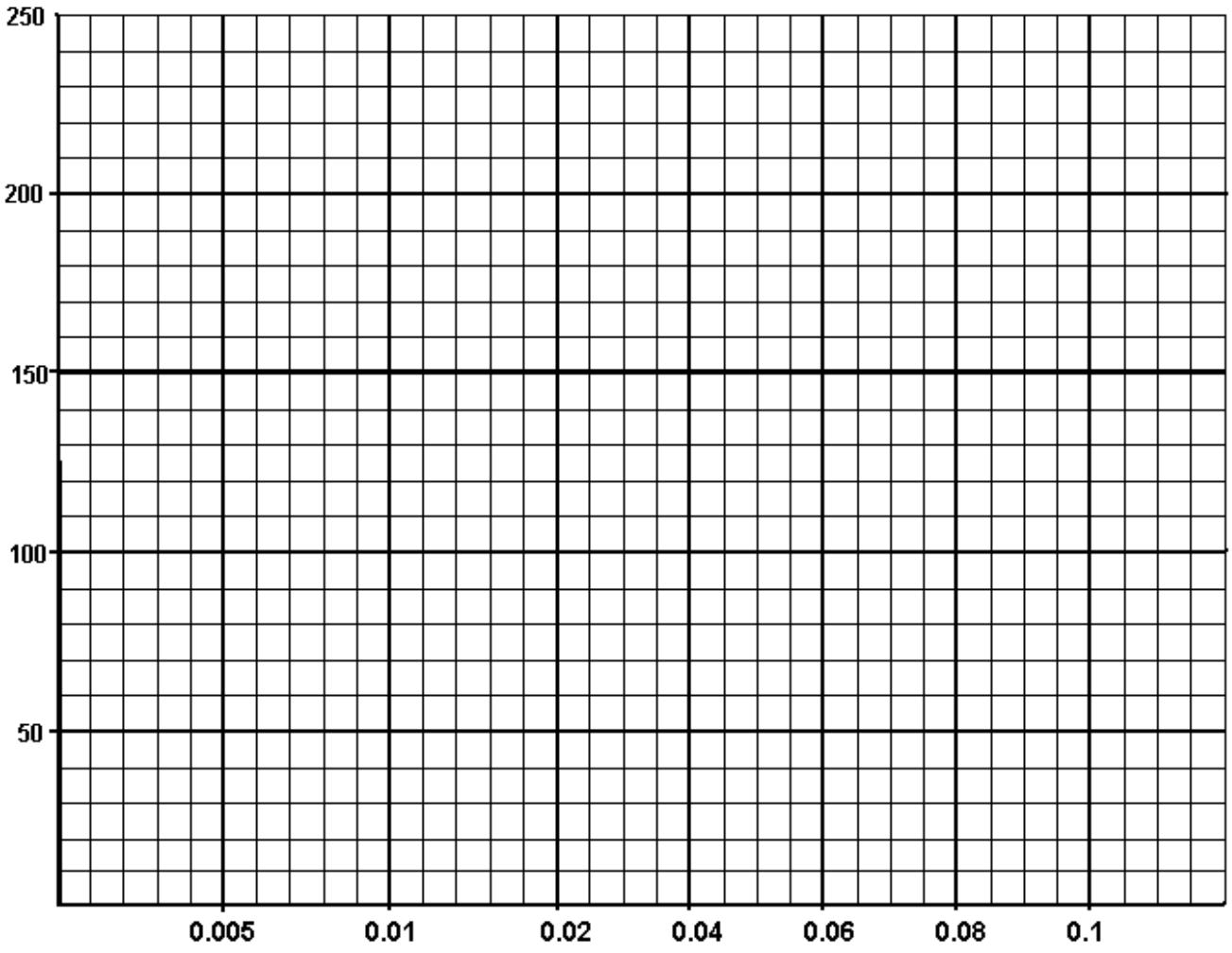
b) At what temperature do we have to heat treat iron to produce the vacancies found in (a) if 30,000 cal are required to produce a mole of vacancies in iron?

Problem 7 (16%)
The following data were collected from a 12-mm-diameter test specimen of magnesium having an initial length l_0 of 30-mm.

Load (N)	**0**	**5,000**	**10,000**	**15,000**	**20,000**	**25,000**	**26,000**	**27,000**	**26,500**	**25,000**
Δl (mm)	**0.0000**	**0.0296**	**0.0592**	**0.0888**	**0.15**	**0.51**	**0.90**	**1.50**	**2.10**	**2.79**

After the fracture the total length was 32.61 mm and the diameter was 11.74 mm. Plot the data on the grid below and calculate:

a) the 0.2% offset yield strength
b) the proportionality limit
c) the tensile strength
d) the modulus of elasticity
e) the % elongation
f) the % reduction in area
g) the modulus of resilience.



Problem 8 (12%)

With the aid of the following phase diagram determine the following:

a. The solubility of tin in solid lead at 100 ºC

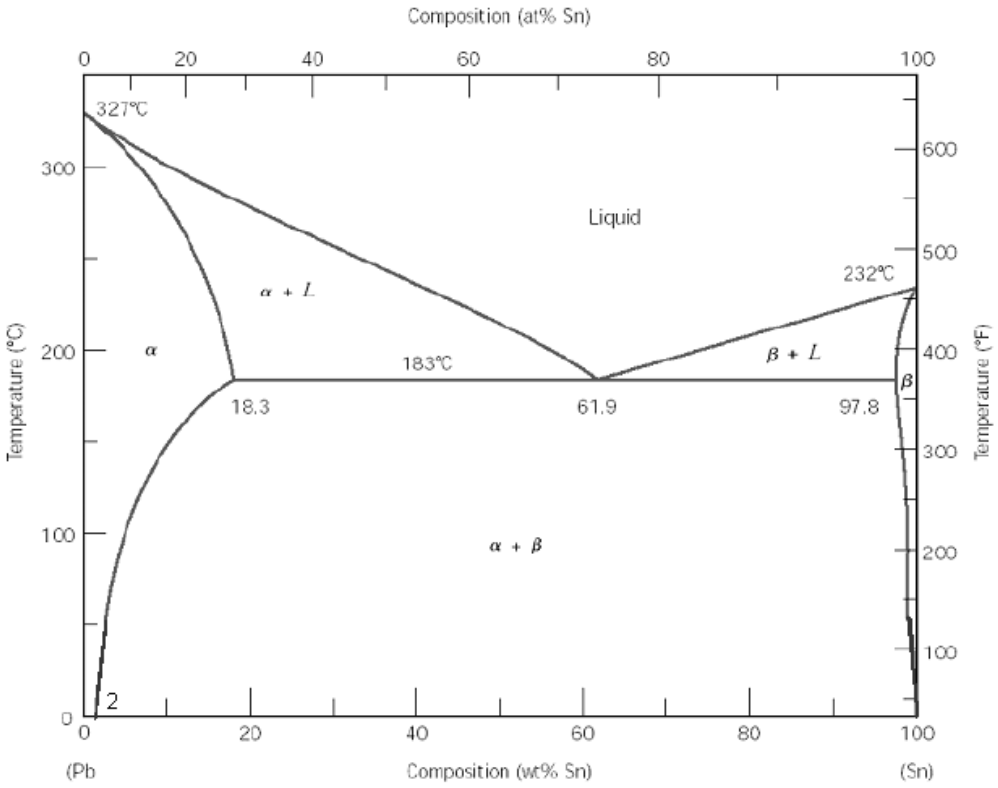
b. The maximum solubility of lead in tin,

c. The amount of β that forms if a Pb-10% Sn alloy is cooled to 0 ºC,

d. The masses of the tin contained in the α, and β phases, and

e. Mass of lead contained in the α, and β phases.

Assume that the total mass of the Pb-10% Sn alloy is 100 grams.



Equations and other data

$$\rho = \frac{nA}{V_C N_A}$$

where :

n = number of atoms per cell

A = Atomic mass

V_c = volume of unit cell

N_A = Avogadro's number, $\left(6.023 \times 10^{23}\ atoms/mol\right)$

$$\frac{4}{3}\pi R^3$$

$$D = D_0 \exp\left(-\frac{Q_d}{RT}\right)$$

R = the gas constant, 8.31 J/mol - K, 1.987 cal/mol - K,
or 8.62×10^{-5} eV/atom - K

$$N_v = N \exp\left(-\frac{Q_v}{RT}\right)$$

$$\frac{C_x - C_0}{C_s - C_0} = 1 - erf\left(\frac{x}{2\sqrt{Dt}}\right)$$

z	***erf*(z)**	***z***	***erf*(z)**	***z***	***erf*(z)**
0	0	0.55	0.5633	1.3	0.9340
0.025	0.0282	0.60	0.6039	1.4	0.9523
0.05	0.0564	0.65	0.6420	1.5	0.9661
0.10	0.1125	0.70	0.6778	1.6	0.9763
0.15	0.1680	0.75	0.7112	1.7	0.9838
0.20	0.2227	0.80	0.7421	1.8	0.9891
0.25	0.2763	0.85	0.7707	1.9	0.9928
0.30	0.3286	0.90	0.7970	2.0	0.9953
0.35	0.3794	0.95	0.8209	2.2	0.9981
0.40	0.4284	1.0	0.8427	2.4	0.9993
0.45	0.4755	1.1	0.8802	2.6	0.9998
0.50	0.5205	1.2	0.9103	2.8	0.9999