UNIVERSITY OF SASKATCHEWAN
COLLEGE OF ENGINEERING

MECHANICAL ENGINEERING (M.E.) 214

ALL SECTIONS
FINAL EXAM
OPEN BOOK **CALCULATORS ARE ALLOWED**

TIME: 3 HOURS **December 2005**

Candidates are to answer all questions.
You are to show your solution in the space below the question.
The reverse side of the page may be used if required.
State all necessary assumptions.

NEATNESS and CLARITY will be considered in the marking of this examination

NAME: _____ Marks
(First Name) (Last Name)

1._____

Name of Lecturing Professor: _____ 2._____

3._____

Student Number: _____ 4._____

5._____

Examination Room: _____ 6._____

TOTAL._____

There are 10 marks for each question.

Note: - make sure you have 6 problems in the exam

Question 1

(a) On unit cells (one for each) of a cubic crystal sketch (212), [221], (121), [112].

(b)

At 200 ^{o}C an alloy containing 85 wt% Pb and 15% wt% Sn consists of a single phase. On average how many of the nearest neighbour atoms of a Pb atom are Sn atoms?

Question 2

If a thick layer of Cu is plated onto Ni, the concentration profile of Cu (in at%) after holding for time t is given by

$$c_X = 50\left[1 - \text{erf}\left(\frac{x}{2\sqrt{Dt}}\right)\right]$$

where x is measured from the original interface and D is the diffusion coefficient.

(a) If it takes twelve hours at 700 ^{O}C for the concentration of Cu to reach 25 at % at a given distance from the original interface, how long would it take at 650 ^{O}C?

(b) Would you expect the distance that Ni diffuses into Cu under the same conditions to be less than, about equal to or greater than the distance Cu diffuses into Ni? Give reasons.

Question 3

A cylindrical rod 20 mm. long and 5 mm. in diameter is made from steel whose tensile engineering stress-engineering strain curve can be represented by:

$\sigma = E\ \varepsilon$	for $\varepsilon < 0.001$
$\sigma = 180$ MPa	for $0.001 < \varepsilon < 0.004$
$\sigma = 167 + 3230\ \varepsilon\ (1 - \varepsilon)$ MPa	for $0.004 < \varepsilon < 0.6$
fracture	for $\varepsilon = 0.6$

(i) 2 If a 3 kN tensile load is slowly applied to the rod what would be the diameter?

(ii) If the 3 kN load is then removed what would be the diameter?

(iii) If a 6 kN tensile load is slowly applied to the rod what would be the diameter?

(iv) If the 6 kN load is then removed what would be the diameter?

(v) After fracture what would be the diameter of the uniform (un-necked) portion?

(vi) If a 6 kN compressive load is slowly applied to the rod and then removed what would be the diameter?

Question 4

The steady state creep rate for some alloys can be shown to follow

$$d\varepsilon/dt = C\,\sigma^{n} \exp(-Q/RT).$$

Given that this relationship exists for an alloy with n = 4 and Q = 200 kJ/mol, calculate what percentage increase in stress will produce the same increase in steady state creep rate as an increase of temperature from 900 °C to 925 °C.

Question 5

(a) 100 kg of a lead-tin alloy are melted and then slowly cooled to just below the eutectic temperature, when the alloy consists of equal amounts of proeutectic α and eutectic mixture. The alloy is then remelted and tin is added. On slowly cooling to just below the eutectic temperature the alloy contains equal amounts of proeutectic β and eutectic mixture.
How much tin was added to the original 100 kg?

(b) A micrograph of a slowly cooled plain carbon steel has 35% of the area proeutectoid phase, the remainder being pearlite.

(i) What is the carbon content?

(ii) In 100 kg of the steel how much ferrite and how much cementite are in the pearlite?

(iii) Sketch the microstructure.

Question 6

(a) A stress of 3 MPa is applied to a rubber band which is then maintained at the stretched length. The stress relaxes to 2 MPa after 10 days. How many days later will the stress in the rubber band be 1 MPa?

(b) A glass has a working point of 1200 ^{o}C and a softening point of 800 ^{o}C. At what temperature should this glass be annealed to remove internal (residual) stresses?

(c) A composite consists of 70 volume % of aligned continuous fibres of tungsten in a copper matrix. What is the specific stiffness?