NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

Faculty of Industrial Technology

Department of Industrial and Manufacturing Engineering

MATERIALS TECHNOLOGY I - TIE 2104

1ST SEMESTETR EXAMINATION - FEBRUARY 2010

Instructions

1. Examination length is **3hrs**.
2. Each question carries twenty **(20)** marks and there are six **(6)** questions in total.
3. Attempt the whole of Section A and three questions from Section B.

SECTION A

QUESTION 1

a) What type(s) of bonding would be expected for each of the following materials: solid xenon, calcium fluoride, bronze, cadmium telluride, rubber, and tungsten? [6]

b) Copper has an atomic radius of 0.128 nm, an FCC crystal structure, and an atomic weight of 63.5 g/mol. Compute its theoretical density. [4]

c) Show for the body-centred cubic crystal structure that the unit cell edge length a and the atomic radius R are related through

$$a = \frac{4R}{\sqrt{3}}$$

[5]

d) Niobium has an atomic radius of 0.1430 nm and a density of 8.57 g/cm^3. Determine whether it has an FCC or BCC crystal structure. [5]

QUESTION 2

a) Explain the term strain hardening. [4]

b) Explain the differences in grain structure for a metal that has been cold worked and one that has been cold worked and then recrystallised. [4]

c) A cylindrical specimen of cold-worked copper has a ductility (% elongation) of 15%. If its cold worked radius is 6.4 mm, what was its radius before deformation? [4]

d) The following tensile strengths were measured for four specimens of the same steel alloy: 520 MPa; 512 MPa; 515 MPa; 522MPa.

i) Compute the average tensile strength . [4]

ii) Determine the standard deviation. [4]

SECTION B

QUESTION 3

a) Construct the hypothetical phase diagram for metals A and B between room temperature (25°C) and 700°C using the following information. [15]

1. Metal A melts at 480°C.
2. The maximum solubility of B in A is 4 weight% B, which occurs at 420°C.
3. The solubility of B in A at room temperature is 0 weight% B.
4. One eutectic occurs at 420°C and 18 weight% B - 82 weight% A.
5. A second eutectic occurs at 475°C and 42 weight % B - 58 weight % A.
6. The intermetallic compound AB exists at a composition of 30 weight% B - 70 weight% A, and melts congruently at 525°C.
7. The melting temperature of metal B is 600°C.
8. The maximum solubility of A in B is 13 weight% A, which occurs at 475°C.
9. The solubility of A in B at room temperature is 3 weight% A.

b) Using the phase diagram constructed determine the relative amounts of the phases present in the eutectic that forms at 420°C. [5]

QUESTION 4

a) A cylindrical specimen of a nickel alloy having an elastic modulus of 207 GPa and an original diameter of 10.2 mm will experience only elastic deformation when a tensile load of 8900 N is applied. Compute the maximum length of the specimen before deformation if the maximum allowable elongation is 0.25 mm [5]

b) A large tower is to be supported by a series of steel wires; it is estimated that the load on each wire will be 13,300 N. Determine the minimum required wire diameter, assuming a factor of safety of 2 and yield strength of 860 MPa for the steel. [6]

c) Explain the difference between substitutional and interstitial solid solutions in metals and the conditions under which they form. [9]

QUESTION 5

a) Write a brief but concise discussion on the applications of materials. [8]

b) From the tensile stress–strain behaviour for the brass specimen shown in Figure Q5, determine the following:

i) The modulus of elasticity. [3]

ii) The yield strength at a strain offset of 0.002. [3]

iii) The maximum load that can be sustained by a cylindrical specimen having an original diameter of 12.8 mm. [3]

iv) The change in length of a specimen originally 250 mm long that is subjected to a tensile stress of 345 MPa. [3]

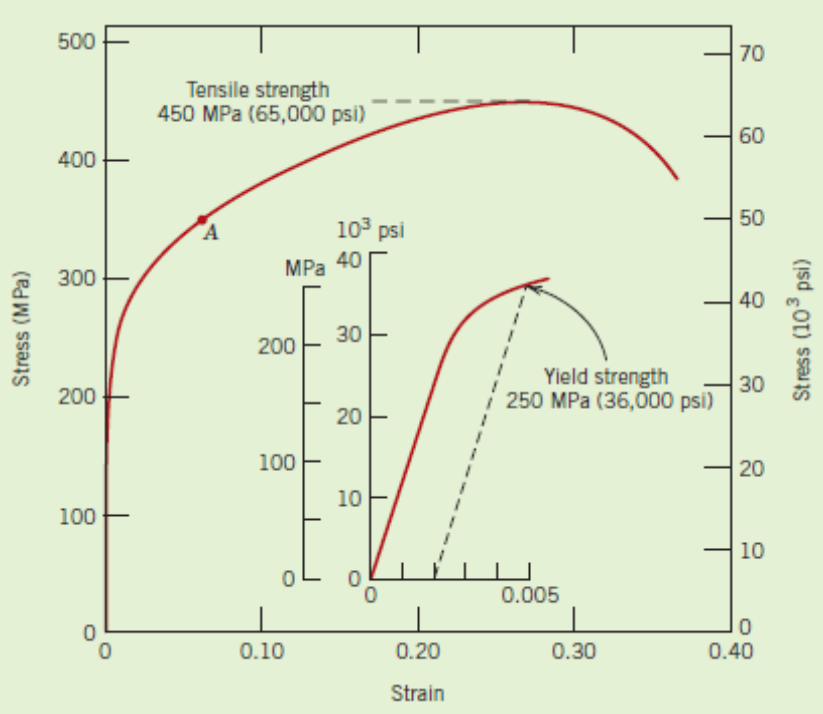

Figure Q5

QUESTION 6

a) The fatigue data for a steel alloy are given below.

Stress Amplitude [MPa (ksi)]	*Cycles to Failure*
470 (68.0)	10^4
440 (63.4)	3×10^4
390 (56.2)	10^5
350 (51.0)	3×10^5
310 (45.3)	10^6
290 (42.2)	3×10^6
290 (42.2)	10^7
290 (42.2)	10^8

Table 6

i) Make an *S–N* plot (stress amplitude versus logarithm cycles to failure) using these data. [6]

ii) What is the fatigue limit for this alloy? [2]

iii) Determine fatigue lifetimes at stress amplitudes of 415 MPa and 275 MPa. [2]

iv) Estimate fatigue strengths at 2 x 10^4 and 6 x10^5 cycles. [2]

b) Discuss the measures that can be taken to improve the fatigue strength of metals [8]

End of Examination