UNIVERSITY OF SASKATCHEWAN
COLLEGE OF ENGINEERING

ELECTRICAL ENGINEERING EE271.3

Midterm Examination
Part B

Instructor: S.O. Kasap November 6, 2002
Time allowed: Part B is nominally 1 hour.
Total time allowed: 2 hours for Parts A and B.

Instructions: Open book examination. *Answer any 2 questions from 3 questions.* All questions carry equal marks. Marks for part–questions are shown in [ ] in the left hand margin. All answers must be given in conventional units. State clearly all assumptions made in your derivations. All answers must be given in conventional units. Method of solution must be clearly shown. Numerical mistakes, incorrect, unconventional or missing units will be heavily penalized. Mention the source of materials data used. Unless otherwise stated all % are in weight % (w/o).

Important: You must hand in Part A before you can start Part B. Write your answers in the university answer book.

Note: You may spend more or less time on Part B; but the total exam time is 2 hours.

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[9] **1.** (a) Nickel (Ni) is a metal with the FCC crystal structure. The radius of the Ni atom is 0.1246 nm. The atomic mass of the Ni atom is 58.69 amu (g mol^{-1}). Calculate the number of Ni atoms per unit volume and density of Ni. Calculate the atomic packing factor of the Ni crystal as %.

[6] (b) Calculate the specific heat capacity of the Ni crystal.

[10] (c) The energy required to create a vacancy in the Ni crystal is 1.4 eV. The thermal expansion coefficient is about $14 \times 10^{-6}\ K^{-1}$. Calculate the concentration of vacancies in the Ni crystal at 700 °C. $\alpha = 3\lambda$ $\mu = \mu_0(1 - \alpha(T - T_0))$

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[12] **2.** (a) The elastic modulus and Poisson's ratio of steel are 210 GPa and 0.27. Consider a 10 meter steel wire of diameter 2.5 mm that is carrying a tensile load of 800 N (equivalent to a mass of about 80 kg, a typical mass of an adult male). The yield strength and the tensile strength of this particular steel are 220 MPa and 400 MPa respectively . What is the new length and diameter of the steel wire? Compare the true and engineering strains and also true and engineering stresses. What is the mass required to fracture the wire?

[13] (b) A tension test is carried out on an steel specimen which has an original diameter of 12.80 mm. After fracture, the diameter at the fractured neck is measured to be 10.4 mm. The original length between two points on the specimen (between gauge marks) is 5.00 cm. After the fracture, this length is 6.10 cm. The maximum load during the test was 55 kN

whereas at fracture the load was 44 kN.

(i) What is the tensile strength?
(ii) What is the true stress at fracture?
(iii) What is the true strain at fracture?
(iv) What is the ductility of the sample?

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[25] 3. (a) A seemingly new radioactive metallic element, called Pz has been discovered on Planet Z^3 by space travelers. The element is believed to have a cubic structure. The atomic mass of the element has been measured to be 209 amu X-diffraction experiments carried out on this new crystal using an X-ray beam with a wavelength $\lambda = 0.1542$ nm (CuKα emission) have given the first six diffraction angles listed in the table below. What is the crystal structure and the lattice parameter? What is the density of the Pz ?

Observed diffraction peaks from an unknown metal cubic crystal.

Peak (first, second etc.)	1	2	3	4	5	6
Diffraction angle, 2θ	26.5°	37.9°	46.8°	54.6°	61.7°	68.4°

SOME CONVERSION FACTORS

LENGTH

1m = 39.37in = 3.280ft = 6.2137×10^{-4}miles
1 in = 0.0254m

ENERGY

1 kJ $mole^{-1}$ = 0.2389 kcal mol^{-1} = 0.010363 eV $atom^{-1}$
1 kcal $mole^{-1}$ = 4.1840 kJ mol^{-1} = 0.043360 eV $atom^{-1}$
1 eV $atom^{-1}$ = 96.490 kJ mol^{-1} = 23.062 kcal mol^{-1}
1 ft lb = 1.356 J 1 BTU = 1055 J
1 erg = 10^{-7} J 1 kWh = 3.600×10^6 J

FORCE

1 N =0.2248 lb 1 lb = 4.448 N

PRESSURE

1 Pa =1 $N.m^{-2}$ = 1.45×10^{-4} psi = 9.869×10^{-6} atm.
1 atm. = 1.013×10^5 Pa = 1.01325 bar = 760 torr (mm Hg)
1 psi = 6.895×10^3 Pa
