THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
DIPLOMA IN TECHNOLOGY – LEVEL 4
FINAL EXAMINATION 2008/2009

MEX 4233 – MATERIALS ENGINEERING
DATE : 20TH MARCH 2009
TIME : 1400 HRS. – 1700 HRS.
DURATION : 3 HOURS

ANSWER 5 PARTS FROM SECTION A & FIVE QUESTIONS FROM SECTION B.

SECTION A

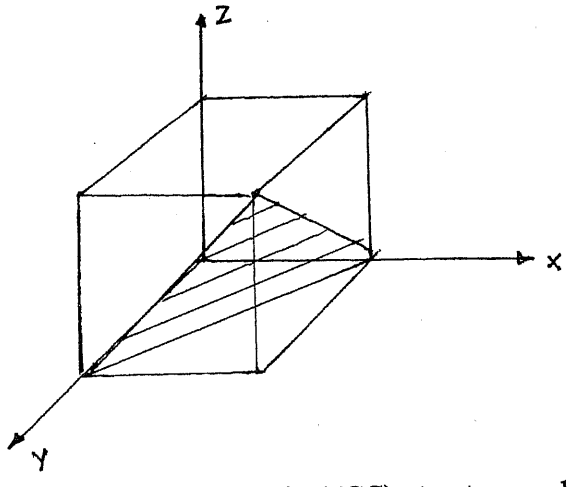
Answer any **Five** parts of this question. Each part carries equal marks

(a) State Hund's rule on pairing of electrons in atoms.

(b) Use a cubic unit cell and illustrate the $(1\ 2\ \bar{1})$ crystallographic plane and the $[1\ 1\ \bar{2}]$ direction.

(c) List & briefly describe the different types of inter atomic bonds present in materials.

(d) Find the Miller indices of the plane shown (hatched) in the following unit cell.



(e) Copper has a Face Centered Cubic (FCC) structure and an atomic radius 1.28^0 A. Calculate the linear density of copper atoms in the [110] direction.

(f) Sketch the BCC unit cell and derive a relationship between the atomic radius 'r' and unit cell parameter 'a'.

(g) Define the terms Space lattice, Unit cell, Atomic Packing Factor & Crystal structure.

(h) Calculate the radius of a Tantalum (Ta) atom given that Ta has a BCC crystal structure, a density of $16.6 g/cm^3$ and an atomic weight of 180.9 g/mole. Avogadro's number is 6.02×10^{23} g/mole.

(20 marks)

SECTION B

Select any **Five** questions. All questions carry equal marks.

1. (a) State Fick's 1st and 2nd laws of Diffusion.

(b) The Diffusion coefficients of carbon in Titanium were determined at the following temperatures.

Temperature (C^0)	Diffusion coefficient (D) m^2/sec.
736	$2x10^{-13}$
782	$5x10^{-13}$
835	$13x10^{-12}$

Assuming that Arrhenius exponential relationship of $D = D_0 \exp(-Q/RT)$ is valid, find the followings.

(a) Constant D_0 of the equation.
(b) Activation Energy Q.
(c) The diffusion coefficient at 500^0C, D_{500}.

(16 marks)

2. (a) What is meant by "Creep" in Engineering materials?

(b) Sketch a typical creep curve for a metal and explain briefly the three characteristic regions.

(c) Discuss the effects of temperature, applied stress and crystal grain size on the creep behaviour of crystalline materials.

(d) Steady state creep data taken for a stainless steel at a stress level of 70 MPa are given as follows.

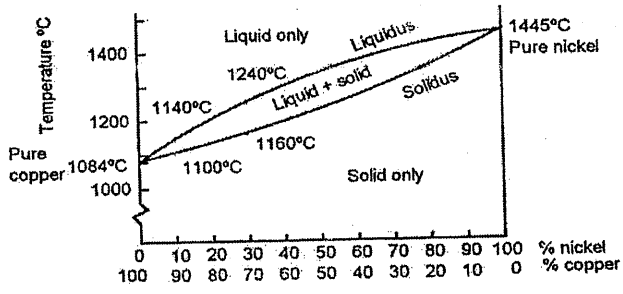
E_{ss} (sec^{-1})	T (K)
$1x10^5$	977
$2.5x10^{-3}$	1089

If it is known that the value of the stress component 'n' for this alloy is 8.0, compute the steady state creep rate.

(16 marks)

3. (a) Derive the lever rule for a binary diagram.

(b)



Shown above is the binary phase diagram of the Nickel-Copper system. Consider an alloy containing 70wt% Nickel and 30wt% Copper, and answer the following.

(i) At 1350^0C make phase analysis assuming equilibrium conditions. In the phase analysis include the following.
What phases are present.
What the chemical composition of each phase is.
What amount of each phase is present.

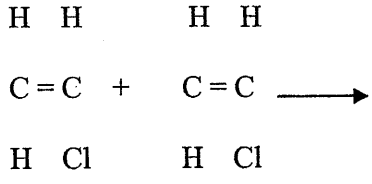
(ii) Calculate the weight percent of liquid and solid present at 1200^0 C.

(iii) Sketch the microstructure of the alloy at temperatures 1350^0C and 1200^0C as observed by circular microscopic fields.

(16 marks)

4. (a) Plastics are widely classified into thermoplastics, thermosets and elastomers. With the aid of a simple diagram show their structural differences and characteristics.

(b) Complete the following reaction in forming a polymer and state the process responsible for such a reaction. Identify and name monomer , mer and polymer produced.



(c) Describe briefly the significance of glass transition temperature in polymers.

(16 marks)

5. (a) What is meant by Fatigue limit or the Endurance limit?

(b) The fatigue data for a steel alloy are given as follows;

Stress Amplitude (MPa)	Cycles to failure
470	10^4
440	$3x10^4$
390	10^5
350	$3x10^5$
310	10^6
290	$3x10^6$
290	10^7
290	10^8

(i) Make an S-N plot (stress amplitude versus logarithm cycles to failure) using these data.
(ii) What is the fatigue limit for this alloy?
(iii) Determine fatigue lifetimes at stress amplitudes of 415 MPa and 275 MPa.
(iv) Estimate fatigue strengths at $2x10^4$ and $6x10^5$ cycles.

(16 marks)

6. (a) What are the crystal imperfections found in materials? Explain them briefly.

(b) At 900^0 C approximately 1 out of 10^9 atoms and at 1000^0C 1 out of 10^8 atoms have enough energy for movement within a solid.

(i) What is the activation energy for this solid?

(ii) At what temperature will 1 out of 10^7 atoms have the required amount of energy for movement?

(16 marks)

7. (a) Explain different types of Ductile failures found in materials.

(b) Explain, how you would identify different types of ductile failures found in such materials.

(16 marks)

8. Discuss and analyze **three** of the following topics from an Engineering view point.

(i) TTT curves
(ii) Hardenability of steel
(iii) Invariant reactions in the Iron-Carbon system
(iv) Mechanical properties of materials
(v) Pilling-Bed worth ratio

(16 marks)

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