The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Diploma in Technology/Bachelor of Technology (Engineering)
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX4233 Materials Engineering**
Academic Year	:	2014/15
Date	:	**20th SEPTEMBER 2015**
Time	:	**0930 HRS. – 1230 HRS.**
Duration	:	3 hours

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

SECTION A

Select any **Five** Parts

(a) Sketch the Face Centered Cubic (FCC) unit cell and derive a relationship between the atomic radius 'r' and unit cell parameter 'a'. Hence find a value for the atomic radius of a Copper atom in nanometers.
Copper is FCC and has a lattice constant of 0.361 nm. **4 marks**

(b) Calculate the planer atomic density on the (110) plane of the α-iron BCC lattice in atoms per square millimeter. The lattice constant of α-iron is 0.287 nm. **4 marks**

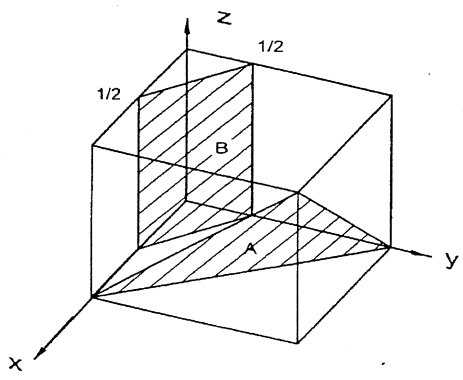
(c) Calculate a value for the density of FCC Silver in grams per cubic centimeter. Lattice constant 'a' of Silver is 0.409 nm and its atomic mass is 107.9 g/mol. Avogadro's number is 6.023×10^{23} mol^{-1}. **4 marks**

(d) Draw the following crystallographic plane and the direction in a cubic unit cell.
(i) (303) (ii) $[1\ \bar{1}\ 3]$
4 marks

(e) Define the terms Space lattice, Unit cell and Atomic Packing Factor (APF) of a crystal lattice. **4 marks**

(f) A 1.3cm diameter rod of an Aluminium alloy is pulled to failure in a tensile test. If the final diameter of the rod at the fractured surface is 1.1cm, what is the percentage reduction in area of the sample due to the test? **4 marks**

(g) Identify the miller indices of the two planes (A and B) shown in Figure below.



4 marks

(h) A 10mm diameter bar of 1040 carbon steel is subjected to a tensile load of 50,000N, taking it beyond its yield point. Calculate the recovery that would occur upon removal of the tensile load. Young's modulus of carbon steel is 200GPa. **4 marks**

SECTION B

1 (a) With the aid of sketches, briefly explain complete solid solubility and partial solid solubility in alloys. **4 marks**

(b) A phase diagram of Magnesium-Lead is shown in Fig.(1) given at the end of the paper.

(i) Label the phase/s in areas 1-6 and name the reaction which occurs at point E.

(Remember to attach the phase diagram with the answer script) **4 marks**

(ii) Considering an alloy containing Pb-45 wt% and Mg-55 wt% state the phase changes that occur when cooling from 700^0C to 0^0C. **4 marks**

(iii) Calculate the amounts of liquid and solid present at temperature 500^0C for the above alloy. **4 marks**

2 (a) List the types of point imperfections found in materials. Explain them briefly. **8 marks**

(b) Calculate the number of vacancies per cubic meter in gold at 900^0C. The energy for vacancy formation is 0.98eV/atom.
The density and atomic weight for Au are 19.32 g/cm^3 and 196.9 g/mol respectively.
Avogadro's number is 6.023×10^{23} mol^{-1}.
Boltzmann constant is 8.62×10^{-5} eV/K. **8 marks**

3 (a) What are the factors that affect the diffusion coefficient? **3 marks**

(b) State Fick's second law of diffusion. **3 marks**

(c) The wear resistance of a steel gear is to be improved by hardening its surface. This is to be accomplished by increasing the carbon content within an outer surface layer by diffusion of carbon into the steel. The carbon is to be supplied from an external carbon rich gaseous atmosphere at an elevated and constant temperature.

The initial carbon content of the steel is 0.20wt%, whereas the surface concentration is to be maintained at 1.00wt%. For this treatment to be effective, a carbon content of 0.60wt% must be established at a position 0.75mm below the surface.
Using the above data, find out the diffusion time required in terms of temperature 'T'.
Diffusion coefficient D_0 for carbon in iron is 2.3×10^{-5} m^2/s and Activation energy Q_d is 148,000 J/mol.
Gas constant R = 8.31 J/mol.K

Error function values are as follows.

Z	Erf (Z)
0.45	0.4755
0.50	0.5205
0.55	0.5633

10 marks

4 (a) Briefly explain the following three polymer categories giving one example for each type.

(i) Thermoplastics
(ii) Thermosetting plastics
(iii) Elastomers **6 marks**

(b) Differentiate between homo-polymers and co-polymers. **4 marks**

(c) An alternating copolymer is known to have a number average molecular weight of 100,000 g/mol and a number average degree of polymerization of 2210. If one of the mers is ethylene, which of styrene, propylene, tetrafluroethylene and vinyl chloride is the other mer? Justify your selection.
Atomic weights: C-12, H-1, F-19, Cl – 35.5
Mer structures are given in Table (4) at the end of the paper. **6 marks**

5 (a) List the strengthening mechanisms which are used to strengthen a material and briefly explain **two** of them. **8 marks**

(b) Briefly discuss the most popular 18-8 stainless steel (18Cr-8Ni). **4 marks**

(c) Why do stainless have corrosion resistant properties? **4 marks**

6 (a) Discuss the effect of following types of failures on materials.

(i) Fatigue

(ii) Creep **6 marks**

(b) Discuss the main characteristic features of a typical fatigue fracture surface. **4 marks**

(c) Discuss briefly the factors which influence fatigue failure of materials. **6 marks**

7 (a) Discuss the types of fibers and matrix materials used in composites. **6 marks**

(b) A unidirectional Kevlar 49-fiber-epoxy composite with 63% by volume of Kevlar 49 fibers is stressed under isostrain conditions. Mechanical characteristics of Kevlar 49 fibers and Epoxy matrix are as follows.

	Tensile modulus of elasticity (GPa)	Tensile strength (MPa)
Kevlar 49 fiber	1895	3800
Epoxy matrix	3.8	75.8

Compute the following for the composite,

(i) The longitudinal Modulus of elasticity. **3 marks**

(ii) The longitudinal Tensile strength. **3 marks**

(iii) The fraction of the load carried by the Kevlar 49 fibers. **4 marks**

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

(a) Types of Primary bonds present in materials.

(b) Invariant reactions in the Iron-Carbon phase diagram.

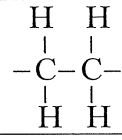
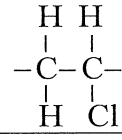
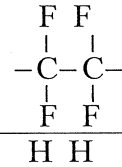
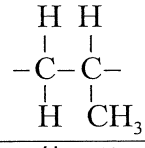
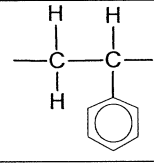
(c) Pilling-Bed worth ratio.

(d) Mechanical properties of materials

(e) Difference between crevice corrosion and stress corrosion cracking.

16 marks

Table (4) – Types of polymers and relevant mer structures.

Polymer	Repeating (mer) structure
Polyethylene (PE)	
Polyvinyl chloride (PVC)	
Polytetra fluoroethylene (PTFE)	
Polypropylene (PP)	
Polystrene (PS)	

Attach this Figure to the answer script.

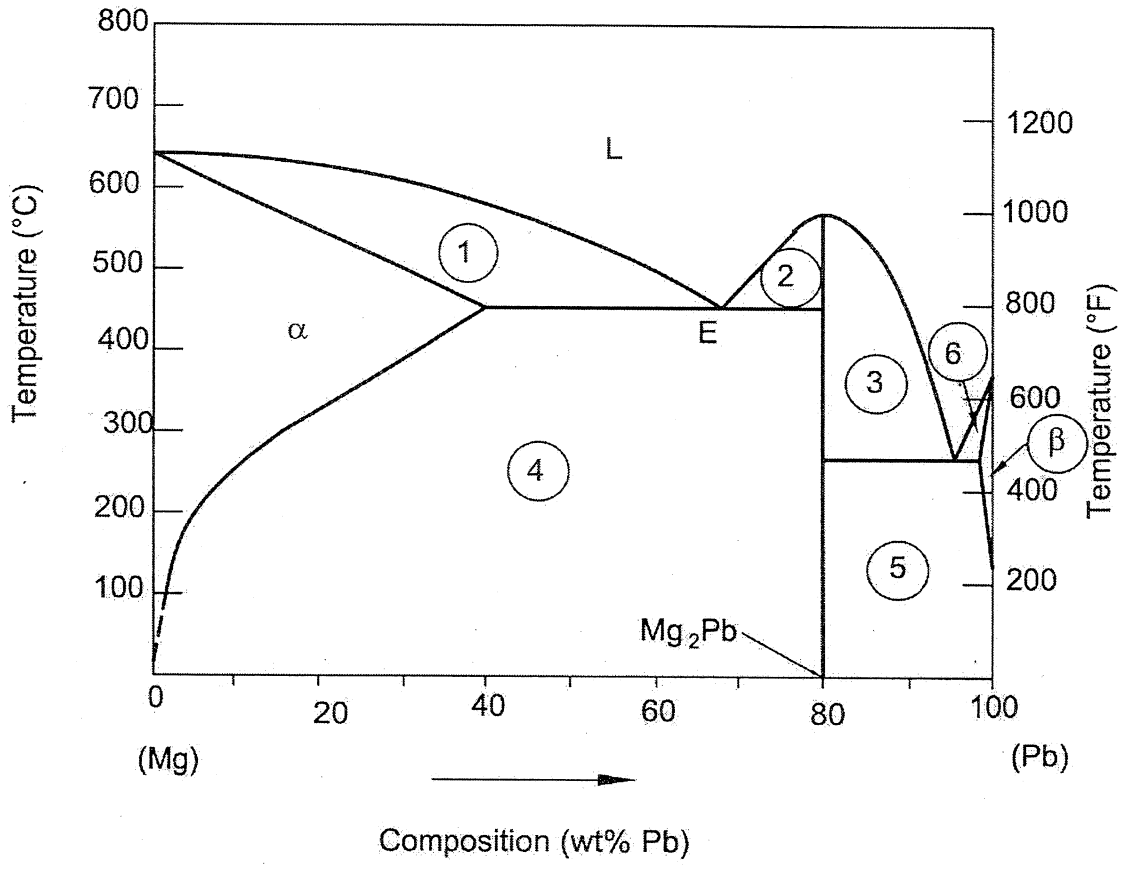


Fig. (1) Magnesium-Lead Phase diagram