OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
DIPLOMA IN TECHNOLOGY – LEVEL 4
FINAL EXAMINATION 2011/2012

MEX 4233 – MATERIALS ENGINEERING
DATE : 3rd MARCH 2012
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) List 5 important Mechanical properties and the type of test that can be used to measure each of the properties.

(b) State Hund's rule on pairing of electrons in atoms giving an example.

(c) Show the following crystallographic plane and the direction in a cubic unit cell.

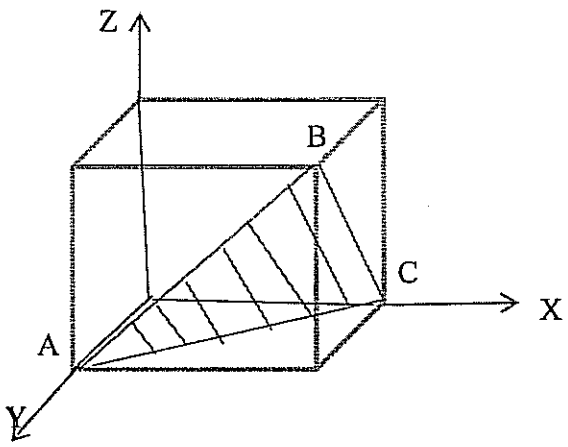
(i) $(3\ 2\ \bar{1})$ (ii) $[3\ 2\ \bar{1}]$

(d) Define the terms Space lattice, Unit cell and Atomic Packing Factor.

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

(f) Calculate the planer density on the (110) plane of the α-iron BCC lattice in atoms per square meter. The lattice constant of α-iron is 0.287 nm.

(g) Find the Miller indices of the plane ABC shown in the following unit cell.



(h) Copper has a FCC crystal structure and an atomic radius of 0.1278 nm. Assuming the atoms to be hard spheres which touch along the face diagonals of the FCC unit cell, calculate a theoretical value for the density of copper in g/cm^3. The atomic weight of copper is 63.5g/mole and Avogadro's number is 6.023×10^{23} atoms/mole.

(20 marks)

SECTION B

1. (a) The diffusion constant D_0 and activation energy Q_d for the diffusion of iron in Cobalt are 1.1×10^{-5} m^2/sec and 253,300 J/mole respectively. At what temperature will the diffusion coefficient have a value of 2.1×10^{-14} m^2/sec? (R=1.99 cal/mole K^0)

   (b) For a steel alloy, it has been found that a carburizing heat treatment of 15 hr duration will raise the carbon concentration to 0.35 wt% at a point 2.0 mm from the surface. Estimate the time necessary to achieve the same concentration of carbon at a point 6.0 mm from the surface at the same carburizing temperature.

(16 marks)

2. (a) List the types of crystal imperfections found in materials. Explain them briefly.

   (b) At 1000^0C, 1 out of 10^8 atoms and at 1200^0C, 1 out of 10^7 atoms have approximately the required energy for movements within a solid. $K_B = 8.617 \times 10^5$ ev/K^0.

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

   (ii) At what temperature will 1 out of 10^6 atoms have the required amount of energy for movement?

(16 marks)

3. (a) Explain how you would strengthen a material using Grain boundary strengthening mechanism.

   (b) Outline the relationship between the yield strength of a material and its grain size quoting the Hall-Petch equation.

   (c) Tensile test on samples of a material having different grain sizes gave the following results.

Yield strength (N/mm^2)	Grain size (mm)
250	0.015
220	0.020

Calculate the following.

(i) Constant terms in the Hall – Petch equation for the material.
(ii) Strength for a grain size of 0.05 mm.

(16 marks)

4. (a)

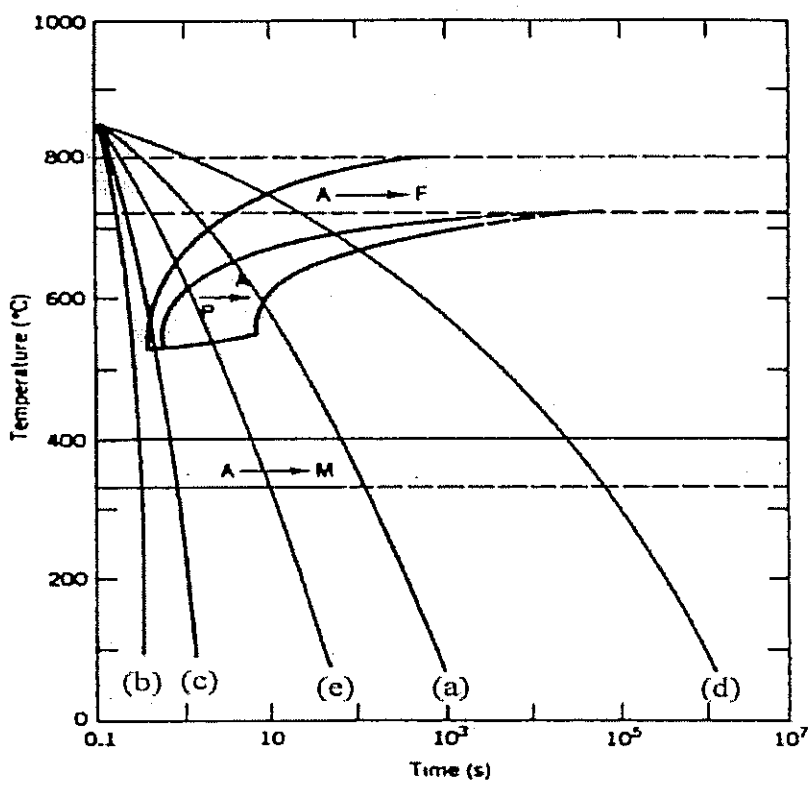


Fig. (4)

The curves (a), (b), (c), (d) & (e) shown in Figure (4) represent different processes of heat treatment such as Annealing, Normalizing & Quenching. Identify the final structure obtained at each of the heat treatment.

(b) What would be the effect on the TTT diagram when adding alloying elements to steel?

(c) How would the TTT diagram change if the carbon content is above or below the eutectoid composition?

(16 marks)

5. (a) What is meant by "creep failure" of materials?

(b) A steel component of 2 meter length in a power plant is subjected to a constant tensile stress of 80 MPa at 500^0C.
Tests at 500^0 C on this steel show that the strain rate ($d\varepsilon/dt$) is $8x10^{-10}$/hr at a stress of 20 MPa and $4x10^{-9}$/hr at 30 MPa.
Assuming that secondary creep rate can be represented by the relationship, $d\varepsilon/dt = B\sigma^n$;

(i) Calculate the constants B and n for the steel.

(ii) Calculate the strain rate at 80 MPa and 500^0C.

(iii) If for this component, the overall extension due to creep should be less than 20 mm at 80 MPa and 500^0C in 5 years time, comment whether or not this steel can be used.

(16 marks)

6. (a) Describe the Injection moulding process used for forming thermoplastic products.
What are the advantages and disadvantages of this process over other processes used for the fabrication of thermoplastic products?

(b) (i) List the types of ductile failures found in metallic materials. Explain them briefly.

(ii) Explain how you would identify each type of ductile failures.

(16 marks)

7. (a) Briefly describe the most popular 18-8 stainless steel (18Cr-8 Ni).

(b) List five Engineering applications of stainless steel.

(c) Explain the problems of welding in using stainless steel.

(d) What is cast iron?
Compare and contrast gray cast iron with nodular cast iron.

(16 marks)

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

(i) Mechanical properties of materials
(ii) Types of bonds present in materials
(iii) Invariant reactions in Iron-Carbon phase diagram
(iv) Hardenability of steel
(v) Three major polymer categories

(16 marks)

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