THE MOMBASA POLYTECHNIC UNIVERSITY COLLEGE

(A Constituent College of JKUAT)

(A Centre of Excellence)

Faculty of Engineering & Technology

DEPARTMENT OF MECHANICAL & AUTOMOTIVE ENGINEERING

UNIVERSITY EXAMINATION FOR:
BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EMG 2104: INTRODUCTION TO MATERIAL SCIENCE

END OF SEMESTER EXAMINATION
SERIES: DECEMBER 2012
TIME: 2 HOURS

Instructions to Candidates:
You should have the following for this examination
- *Answer Booklet*

This paper consists of **FIVE** questions. Answer any other **THREE** questions
Maximum marks for each part of a question are as shown
This paper consists of **THREE** printed pages

Question One

a) Giving and example, describe the following type of bonds:
(i) Covalent bond
(ii) Metallic bond
(iii) Ionic bond **(4½ marks)**

b) Discuss Polymorphism with particular reference to iron. **(2 ½ marks)**

c) On a cubic unit cell, sketch the following planes

(i) (100) (ii) (110) (iii) (101) **(3 marks)**

d) A metal with FCC structure has unit lattice dimension 0.41025nm. For this metal, calculate the distances between successive (100), (110) and (111) planes. **(5 marks)**

e) When X-rays of wavelength 0.1537nm are directed towards a crystal of KCl, order one diffraction occur at a bragg angle of 14^{o}.

(i) Calculate the distance between the layers of ions in the crystal.
(ii) What is the order two Bragg angle?
(iii) What is the volume of unit lattice cube of KCl? **(5 marks)**

Question Two

a) Using the force/extension data below for a specimen original $\phi 11.26mm$ and fracture $\phi 9.34mm$, plot the force extension diagram and determine:
(i) Tensile strength
(ii) Modulus of elasticity
(iii) 0.2% proof stress
(iv) % reduction in areas
(v) Truss stress at a nominal strain of 8% (assume appropriate gauge length)

Force KN	39.4	67.5	84.4	90.0	95.6	112.5	123.8	131.1	131.1	123.8
Extension (mm)	0.25	0.4	0.5	0.6	0.75	1.75	3.0	5.0	6.5	8.0

(15 marks)

b) Define the following material properties:
(i) Brittleness
(ii) Malleability
(iii) Toughness
(iv) Yield point
(v) Elongation
(vi) Reduction in area **(3 marks)**

c) Briefly outline the charpy/impact test. **(2 marks)**

Question Three

a) Two metals A and B are mutually soluble in all proportions in the liquid state and are completely insoluble in the solid state. Metal A melts at $280^{o}C$ while metal B melts at $320^{o}C$. The two metals form a eutectic at $140^{o}C$ of composition 60% A and 40% B. Draw a phase diagram to scale and label all the phase fields. **(6 marks)**

b) From the diagram explain how the phase transformation takes place and the final structure of the following two alloys when cooled under equilibrium conditions from the liquid state to the solid state.
(i) An alloy containing 20% A and 80% B
(ii) An alloy containing 80% A and 20% B. **(6 marks)**

c) Determine the relative amounts of the phases present at 175°C for the two alloys:

(i) 20% A and 80% B

(ii) 80% A and 80% B **(4 marks)**

Question Four

a) Describe the following mechanical tests:

(i) Torsion

(ii) Compression

(iii) Fatigue

(iv) Brinell Hardness **(16 marks)**

b) On a Brinell Test on cold worked Copper the load was 30kg, diameter of the ball was 1mm and the diameter of the impression was 0.596mm. Calculate the Brinell Hardness of cold worked Copper. **(4 marks)**

Question Five

a) Describe the following physical properties:

(i) Thermal conductivity

(ii) Magnetic

b) Using a sketch, describe the following crystal defects:

(i) Edge dislocation

(ii) Void

(iii) Coherent precipitate **(6 marks)**

c) Discuss the phenomena of ductile/brittle transition. **(4 marks)**

d) A certain mild steel specimen was observed to have a strength of 495.577N/mm^2 when the diametral grain size was 6 μm. On heat treatment the specimen showed a strength of 4591.187N/mm2 when the diametral grain size was 7 μm.

(i) Determine the constants in the Hall/Petch relation

(ii) What would the diametral grain size have to be if the strength desired is 527N/mm^2? **(6 marks)**