MAASAI MARA UNIVERSITY

REGULAR UNIVERSITY EXAMINATIONS
2017/2018 ACADEMIC YEAR
THIRD YEAR *SECOND* SEMESTER

SCHOOL OF SCIENCE
BACHELOR OF SCIENCE

COURSE CODE: PHY 316

COURSE TITLE: INTRODUCTION TO MATERIALS SCIENCE

DATE: **20th August 2018** **TIME: 830-1030**

INSTRUCTIONS TO CANDIDATES

1. Answer Question **ONE** and any other **TWO** questions
2. Use of sketch diagrams where necessary and brief illustrations are encouraged.
3. Read the instructions on the answer booklet keenly and adhere to them.

*This paper consists of **four** printed pages. Please turn over.*

QUESTION ONE: [30 marks]

(a) Differentiate between materials science and materials engineering. (2 marks)

(b) (i) Sketch a relationship between force and interatomic spacing between atoms in a material, as well that of energy versus interatomic spacing.(2, 2 marks)

(ii) Describe the following bond types in materials; primary, secondary. (1, 1 marks)

(iii) Define the term material property. (1 mark)

(c) (i) Define an amorphous material. (1 mark)

(ii) Show with the help of a diagram that the cube edge in an FCC lattice is, $a = 2R\sqrt{2}$, where R is the (spherical) atomic sphere radius. (2 marks)

(iii) Write down an expression for its atomic packing fraction (APF). (2 marks)

(iv) Hence, show that the atomic packing fraction for a FCC structure with atoms having the same diameter is 0.74. (2 marks)

(d) (i) How would the modulus of elasticity compare with the melting point of a given material. (1 mark)

(ii) Define anelasticity, and explain why it occurs. (2 marks)

(e) Differentiate with the aid of a diagram between the shapes of indenters used in determining a material's hardness Vickers micro-hardness and Rockwell hardness tests. (4 marks)

(f) Define the term 'thermal property' as used in the study of materials. (1 mark)

(g) Define diamagnetism and explain its origin. (2 mark)

(h) A cylindrical specimen of steel having an original diameter of 12.8 mm (0.505 in.) is tensile tested to fracture and found to have an engineering fracture strength σ_f of 460 MPa (67,000 psi). If its cross-sectional diameter at fracture is 10.7 mm (0.422 in.), determine the ductility in terms of percent reduction in area. (3 marks)

(i) Define hardness, resilience and toughness. (1,1,1 marks)

QUESTION TWO: [20 marks]

a. Show that the refractive index n of a material is $\eta = \sqrt{\varepsilon_r \mu_r}$, where the symbols have their usual meanings. (4 marks)

b. Give brief descriptions and uses of the following classes of materials:

   i. Phonon

   ii. Thermal stress (2, 2, marks)

c. Calculate the minimum and maximum bandgap energies for which there is absorption of visible light in metals (minimum visible light wavelength = 4×10^{-7} m, minimum visible light wavelength = 7×10^{-7} m, Planck's constant = 4.13×10^{-15} eV.s) (4 marks)

d. Differentiate between thermoplastic and thermosetting polymers. (2 marks)

e. Calculate the atomic radius in cm for the following: (i) BCC metal with a_o = 0.3294 nm and one atom per lattice point; and (ii) FCC metal with a_o = 4.0862Å and one atom per lattice point. (2, 2 marks)

f. Explain how temperature gradient induced stresses comes about in materials. (4 marks)

QUESTION THREE: [20 marks]

(a) (i) Distinguish between elastic and plastic deformation. (2 marks)

(ii) State three ways by which plastic deformation occurs in materials. (3 marks)

(b) A piece of brass, originally 300 mm long is pulled in tension with a stress of 270 MPa. If the deformation is purely elastic, what would be the resultant elongation, given that Y=97GPa for brass? (3 marks)

(C)(i) Write an expression for the Poisson's ratio ν of an elastic isotropic material. (1 marks)

(ii) A tensile stress is to be applied along the long axis of a cylindrical brass rod

that has a diameter of 10mm. Determine the magnitude of the strain required to produce a 2.5×10^{-3}mm change in diameter, if deformation is mainly elastic. Poisson's ratio for brass is 0.34. (7 marks)

(iv) Distinguish between fatigue and creep failure. (2 marks)

QUESTION FOUR: [20 marks]

(a) What is a magnetic dipole. (2 marks)

(b) How do the following magnetic parameters relate with each other, (a formula may help in explanation).

(i) Magnetic field and magnetic field strength

(ii) Permeability in a material to the permeability in a vacuum

(iii) Magnetization and magnetic field strength

(iv) Magnetic susceptibility and the relative permeability. (2, 2, 2, 2 marks)

(c) Explain the origin of magnetic moments in electron. (2 mark)

(d) Calculate **(i)** the saturation magnetization and **(ii)** the saturation flux density for nickel, which has a density of 8.90 g/cm^3 given that Bohr magnetons $(\mu_B) = 9.27 \times 10^{-24}$ A.m^2 . (7 marks)

(e) Define the term birefringence. (1 mark)