MACHAKOS UNIVERSITY

University Examinations 2020/2021 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (APPLIED PHYSICS AND TECHNOLOGY)

SPH 309: MATERIAL PHYSICS

DATE: 13/8/2021 **TIME: 2.00-4.00 PM**

INSTRUCTIONS:

Answer question **ONE** which is compulsory and any other **TWO**

QUESTION ONE (30 MARKS)

a) What is meant by equilibrium distance of particles (2 marks)

b) The attractive force between ions with unlike charges is given by $\frac{e^2}{4\pi\varepsilon\, r^2}$ while the repulsive force is $\frac{ce^2}{r^n}$, where c is a constant, n is an exponent while e is the electronic charge

i. Determine an expression for the equilibrium distance, d (4 marks)

ii. Show that the energy E is given by $E = \left(\frac{n-2}{n-1}\right)\frac{e^2}{4\pi\varepsilon\, d^2}$ (4 marks)

c) i Derive an expression for the shear modulus of a body (4 marks)

ii A block of effective area 0.8 m by 5 cm experiences a shearing force that displaces it by 0.016 cm. Determine the magnitude of this shearing force (3 marks)

d) Distinguish uniform and steady flow (3 marks)

e) Describe each of the following bonds(i) Molecular bonds (3 marks)

(ii) Van der Waals bonds (3 marks)

f) Sketch the relationship between the resultant potential energy and distance between particles, indicating the types of energy involved (4 marks)

QUESTION TWO (20 MARKS)

a) A variable force is exerted on an elastic body until it breaks. By sketching the relationship between stress and strain, describe the curve. (10 marks)

b) i Distinguish critical and terminal velocity (2 marks)

ii Using the forces acting on a body moving in a long column of a viscous fluid, show that its terminal velocity is constant (8 marks)

QUESTION THREE (20 MARKS)

a) Explain why materials under tension are more likely to fracture along planes of 45^{o} to the direction of the shearing force (4 marks)

b) For small angles of shear, show that the: -

i. Shear modulus, G is inversely proportional to the angle of shear (4 marks)

ii. Theoretical maximum stress on a body $\tau_{max} = 0.16\ G$ (4 marks)

c) Giving four reasons, explain why the breaking stress is far much lower than the theoretical value obtained in (b) (ii) (8 marks)

QUESTION FOUR (20 MARKS)

a) i Describe rusting process (2 marks)

ii Explain six ways of preventing corrosion (6 marks)

b) i What is meant by a neutral axis (2 marks)

ii Derive an expression for the stress at any distance y from the neutral axis in terms of the Young's modulus, E for a beam that was initially straight and thereafter bend until the radius at the neutral axis is R. (6 marks)

iii Calculate the maximum stress in a rectangular concrete beam, 20 cm wide and 30 cm thick if the radius from neutral axis R= 1.2 m? (Young's modulus of concrete, E = 206 GN/m^{-2}) (4 marks)

QUESTION FIVE (20 MARKS)

a) Explain three advantages of alloying (6 marks)

b) Discuss the mechanical properties of reinforced polymers (7 marks)

c) Glass fibers have a strength of 2 GN/m^2 and a density of 2600 kg/m^3 while epoxy resin has a density of 1200 kg/m^3. 6 kg of glass fibers are added to 5 kg of epoxy resin to form aligned continuous glass fiber reinforced plastic composite. Determine the: -

i. fiber volume ratio (4 marks)

ii. strength of the composite assuming that it corresponds to the fiber fracture. (3 marks)