MACHAKOS UNIVERSITY

University Examinations 2016/2017

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR APRIL SESSION EXAMINATION FOR BACHELOR OF EDUCATION

SPH 302: STRUCTURE AND PROPERITES OF MATTER

DATE: SCHOOL BASED **TIME:**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

Required data and constants:

- *Earth's gravitational pull = 9.8 N/Kg*
- *The Universal Gravitational Constant G = 6.67 × 10 $^{-11}$ N.m^2/Kg^2*
- *Viscosity of water and glycerin are 1.0 x 10^{-3} N.s/m^{2}and 1500 x10^{-3}N.s/m^2 respectively*
- *Density of water is 1g/cm^3*
- *1 atmospheric pressure = 1.01 x 10^5 N/m^2*
- *Density of glycerin1.26 x 10^{3}kg/m^3*
- *Gravitational acceleration g= 9.8 m/s^2*
- *Avocadro number = 6.02 x 10^{23}*
- *The thermal conductivity of Styrofoam = 0.010 Js^{-1}m^{-1}k^{-1}*
- *Latent heat of fusion of ice = 333 kjKg^{-1}*

SECTION A (COMPULSORY)

QUESTION ONE (COMPULSORY) (30 MARKS)

a) i. Distinguish between crystalline and amorphous solids (3 marks)

ii. What do you mean by space lattice and unit cell of a crystal (2 marks)

iii. Explain why crystalline solids have a sharp melting point while amorphous solid melt over a temperature (3 marks)

iv. Distinguish between crystal lattice and crystal structure (2 marks)

b) i. By use of dimensional analysis show that surface tension and surface energy refers to the same quantity (4 marks)

ii. Distinguish between shear stress and shear strain (3 marks)

iii. Define the term diffusion gradient (2 marks)

iv. State the significance of Maxwell Boltzmann distribution (2 marks)

c) i. State three factors that affect volume flux of a given fluid (3 marks)

ii. In words, state Bernoulli's equation (2 marks)

iii. State four characteristics of an ideal gas (4 marks)

QUESTION TWO (20 MARKS)

a) i. Explain the term 'Miller indices'. What is the role in crystal structure (3 marks)

ii. A plane makes intercepts as 4**a**, 3**b** and 2**c**, where **a**, **b** and **c** are lattice vectors. Write the Miller indices of the plane in the form (hlk) (3 marks)

iii. Sketch a diagram to illustrate the (111) plane (3 marks)

b) A capillary tube with an inside diameter of 450 μm can support a 150 mm column of liquid that has a density of 1000 kg.m^3. The observed contact angle is 20^0. Find the surface tension of the liquid. (4 marks)

c) Consider a solid cylinder of fluid, of radius *r* inside a hollow cylindrical pipe of radius *R* with length *L*. Show that the volume flux of the fluid is given by Poiseuille's equation below

$$\frac{dV}{dt} = \frac{\pi.\Delta P.\mathrm{R}^4}{8\eta L}$$

where ΔP is the pressure difference and η is the viscosity of the fluid (7 marks)

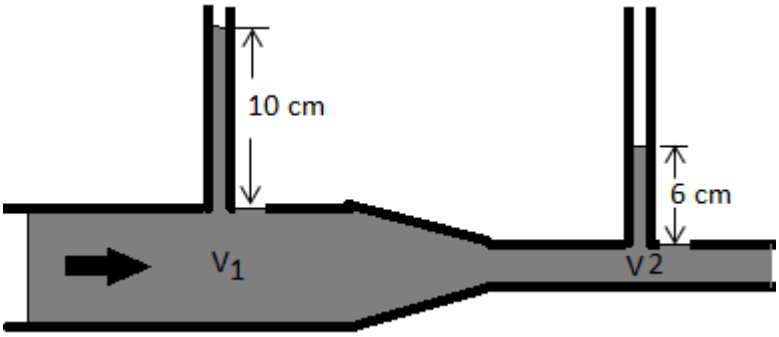
QUESTION THREE (20 MARKS)

a) i Derive an expression for the coefficient of viscosity (η) (4 marks)

ii Hence show that the SI units of coefficient of viscosity (η) are $kgm^{-1}s^{-1}$

(2 marks)

b) The inside diameter of the wider section of the tube is 2.5 cm while diameter at the constriction is 1.5 cm.



i. Show that (7 marks)

$$V_2 = \sqrt{\frac{2(P_1 - P_2)}{(1 - A_2^2/A_1^2)}}$$

ii. Hence calculate velocity V_2 (5 marks)

c) Explain why the blood is a viscous fluid but does not follow Poisseulle's equation

(2 marks)

QUESTION FOUR (20 MARKS)

a) i. How many lattice points are there in a body centered cubic cell? Explain how you arrive at your answer. (2 marks)

ii. Define the terms packing fraction and atomic radius (2 marks)

iii. Show that the bcc lattice of side length *a*, the atomic radius, *r*, is given by

$$r = a\frac{\sqrt{3}}{4}$$

(4 marks)

iv. Calculate the nearest neighbor distance for face centered cubic lattice (2 marks)

b) Calculate the packing fraction for the following various Crystal structures:

i. Simple cubic crystal structure (2 marks)

ii. Face centered cubic crystals (2 marks)

iii. Body centered cubic crystal (2 marks)

c) An oil drop has a density of 930 kgm^{-3}. The terminal velocity of a spherical drop of oil falling in air at 20^0 is 0.18 ms^{-1}. At 20^0 c, air density is 1.2 kgm^{-1} and its viscosity is 18×10^{-6} Pa.s. Find the radius of the droplet. (4 marks)

QUESTION FIVE (20 MARKS)

a) Reynold's number, N_R, indicates as to whether a fluid flow in a laminar or turbulent. Show that it is given by:

$$N_R = \frac{2\rho\bar{v}R}{\eta}$$

where ρ is the fluid density, v the fluid velocity, R the pipe diameter and η the viscosity of the fluid. (4 marks)

b) A pipe with diameter 300 mm has water (density 1000 $kg.m^{-3}$, viscosity 1 mPa.s), flowing through it. Find Reynold's number for the flow when there is a flow speed of 3 $mm.s^{-1}$. (3 marks)

c) Using appropriate diagram, explain how the rate of heat transfer through composite materials is determined. (3 marks)

d) A Styrofoam picknic chest has dimensions 0.5m × 0.3m × 0.35m with walls 0.02m thick.

i. If the temperature difference across the walls is 35^0 c, at what rate will the heat be conducted out of or into the chest (4 marks)

ii. How many kilograms of ice do you need to put in the chest to keep the beer at 0^0 c for 5 hours. Assume that the beer was initially cooled to 0^0 c. (4 marks)

e) Define the term transport property of a substance. Give one example of transport property. (2 marks)