MACHAKOS UNIVERSITY

University Examinations for 2019/2020 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF EDUCATION (SCIENCE)

SPH 302: STRUCTURE AND PROPERTIES OF MATTER

DATE: 13/11/2020 **TIME: 11:00 – 1:00 PM**

INSTRUCTIONS:

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

The following constants may be useful:
Density of steel, glycerine, air, mercury and blood are 7.7 g/cm^3, 1.26 g/cm^3, 0.001225 g/cm^3, 13.6 g/cm^3 and 1.050 g/cm^3 respectively. Gravitation acceleration 9.8 m/s^2. Surface tension of water 0.073 N/m^2, coefficient of thermal conductivity of glass 1.1 W$m^{-1}K^{-1}$, Reynold number of blood flowing in a human artery N_R=3000, viscosity of blood 2.7 x $10^{-3}N.sm^{-2}$, viscosity of air 1.8 x $10^{-3}N.sm^{-2}$

SECTION A
QUESTION ONE (COMPULSORY) (30 MARKS)

a) Using a drawing, show that, in crystals, the axis of symmetry can only be two, three, four or six-fold and not 5 or 7-fold. Give a reason why this is so. (2 marks)

b) In an experiment to study blood circulation in a human artery, it was noted that, flow turned turbulent at a speed of 38.5 m/s. Calculate the radius of the artery. (4 marks)

c) Calculate Madelung constant for sodium chloride in 3 dimension (6 marks)

d) The shaded plane in figure 1, represent a face of a crystal, identify the miller indices of the crystal. (4 marks)

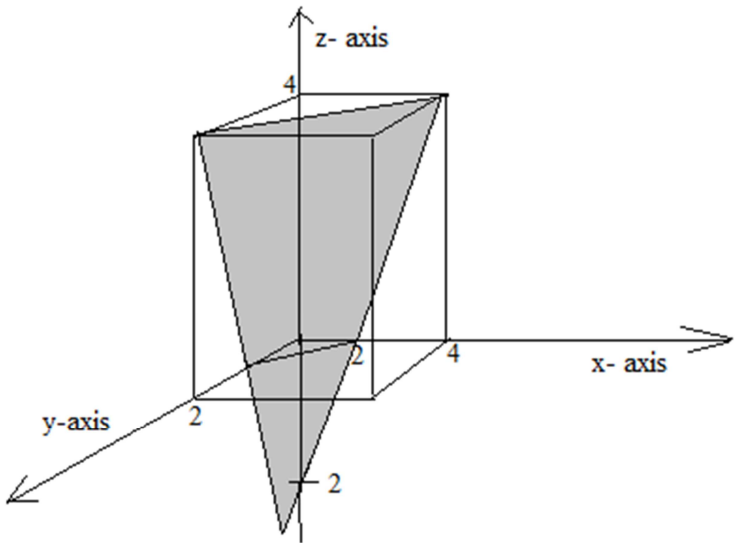

Figure 1

e) Distinguish between an ionic and a covalent crystal. (2 marks)

f) Derive Bragg's law. (2 marks)

g) X-rays with a wavelength of 0.154 nm at 34.5^0 angle of incidence, undergo diffraction from a crystal of lattice separation distance d = 0.136 nm.

i) Find the order at which this diffraction occurs (3 marks)

ii)Calculate the angle at which third order diffraction will occur? (3 marks)

h) Explain how Bernoulli's equation adjusts, if

i. a flowing fluid in a pipe speeds up.

ii. the pipe carrying a flowing pipe is horizontal (4 marks)

SECTION B: ANSWER ANY OTHER TWO QUESTIONS

QUESTION TWO (20 MARKS)

a) A giraffe's heart pumps blood to its head with an output velocity of 2 m/s and a gauge pressure of 4.0 x 10^5 pa. The inside diameter of the artery at the heart outlet is 2.5 m/s while at the head inlet is 1.5 cm. Calculate

i) Blood flow speed as it enters the brain (3 marks)

ii) If the gauge pressure as the blood enters the brain is 3.5x10^5 pa, and the height of the giraffe from the ground to its head is 8 metres, approximate the height of the giraffe's neck. (6 marks)

b) Consider rate of flow of heat (J/s) in a thin disc of some material of cross-sectional area A and thicknessδx. Suppose that the hotter section is at a temperature θ and that the colder section is maintained at $\theta - \delta\theta$. Derive an expression for coefficient of

thermal conductivity of the material. (6 marks)

c) Describe an experiment you can perform to determine coefficient of viscosity η using Stokes's law (5 marks)

QUESTION THREE (20 MARKS)

a) Suppose Chinese were to create a standard gauge train, with looks like a millipede with 3000 legs to walk over water. If the greatest mass of this train were 10.0 x 10^3 kg, calculate the surface area of each leg. (7 marks)

b) Calculate the terminal velocity a steel ball bearing 2.00 mm in diameter fall in a glycerine of viscosity 0.150 N.s/m^2 (6 marks)

c) A glass slab of a thermal insulator with a cross-sectional area of 100 cm^2 is 3.00 cm thick. If the temperature of the hotter side is 300 ℃ and that of the cooler side is 8 ℃, calculate amount of heat that flows through the slab in 1 day? (7 marks)

QUSTION FOUR (20 MARKS)

a) A copper sphere with a mass of 0.20 g and a density of 8900 kg/m^3 is observed to fall with a terminal speed of 6 cm/s in glycerine. Calculate

i) Radius of the sphere (3 marks)

ii) the viscosity of glycerine. (5 marks)

b) A fluid of density ρ flows through a pipe of cross section area A_1 at the inlet and A_2 at the outlet. Show that the pressure difference between the two points is

$$\Delta P = \frac{V^2\rho(1-A_2^2/A_1^2)}{2}$$ (5 marks)

c) At one point in a pipeline, the water's speed is 3.00 m/s and the gauge pressure is 4.0 x $10^4 pa$ Find the gauge pressure at a second point in the line 110 m lower than the first if the pipe's diameter at the second point is a third of that at the first. (7 marks)

QUESTION FIVE (20 MARKS)

a) A horizontal pipe shown has a cross section area of 40 cm^2 at the wider portions and 10 cm^2 at the constriction as shown in Figure 2. Water is flowing in the pipe and the discharge from the pipe is 8.0 x $10^{-3} m^3$/s.

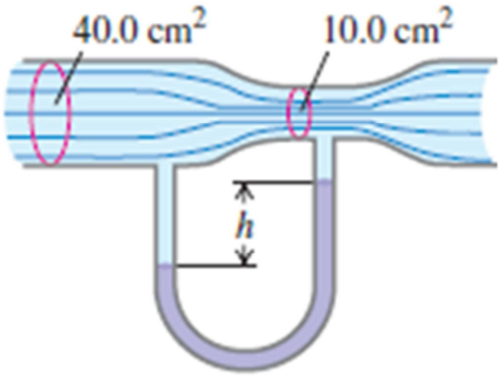

Figure 2

Calculate

i) The flow speeds at the wide section (2 marks)

ii) Flow speed at narrow section (3 marks)

iii) Pressure difference between the wide and narrow portions (4 marks)

iv) The difference in height between the mercury columns in the U– shaped tube (3 marks)

b) A fatally wounded patient in a hospital receives IV blood transfusion through a needle of 0.30 mm and length 3 cm. If the bottle supplying blood to the patient is placed 1.3 m above the patient and the venous pressure is 5.0 x 10^3pa, calculate the blood flow rate into the patient (Ignore atmospheric pressure) (8 marks)