MACHAKOS UNIVERSITY

University Examinations 2021/2022

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF SCIENCE (APPLIED PHYSICS AND TECHNOLOGY)

BACHELOR OF EDUCATION SCIENCE AND BACHELOR OF EDUCATION (SPECIAL NEEDS EDUCATION)

SPH 302: STRUCTURE AND PROPERTIES OF MATTER

DATE: 18/03/2022 **2:00 -4:00PM**

INSTRUCTIONS:

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

CONSTANTS

- Take: Coefficient of viscosity of air $= 1.8 \times 10^{-4}$ poise
- Density of air $= 1.3\ kgm^{-3}$
- Avogadro's number $= 6.04 \times 10^{23}$
- Boltzmann's constant $= 1.38 \times 10^{-23} JK^{-1}$
- Gravitational acceleration, g $= 9.8\ ms^{-2}$
- Atmospheric pressure $= 76cmHg$
- Density of Mercury $= 13.6\ gcm^{-3}$

SECTION A

QUESTION ONE (30 MARKS)

a) Briefly state how the three states of matter differ. (3 marks)

b) State and sketch the four different lattice types of the orthorhombic system. What restrictions on conventional cell axes and angles differentiate this system from the other systems. (7 marks)

c) A certain orthorhombic crystal has axial units a: b:c of 0.424:1:0.367. Calculate the miller indices of crystal faces whose Weiss indices are:

i) 0.212:1:0.183

ii) 0.424:∞:0.123 (6 marks)

d) Explain briefly any three physical evidences of the existence of molecules and their motion (3 marks)

e) State Bernoulli's theorem. A tank containing water has an orifice in one vertical side. If the centre of the orifice is 300 cm below the surface level in the tank, calculate the velocity of efflux (velocity of discharge) assuming no wastage of energy (4 marks)

f) In a crystal whose primitives are 1.2 A˚, 1.8 A˚ and 2 A˚, a plane whose miller indices are (231) cuts intercept 1.2 A˚ along x-axis. Calculate the lengths of the intercepts along y and z axes (4 marks)

(g) A substance with fcc lattice has density $6250\ \mathrm{kg/m^3}$ and molecular weight 60.2. Calculate the lattice constant. (3 marks)

SECTION B

QUESTION TWO (20 MARKS)

a) A horizontal tube of 1 mm bore is joined to another horizontal tube of 0.5 mm bore. Water enters at the free end of the first tube at a pressure equal to 50 cm of water above the atmospheric pressure and leaves at the free end of the second tube at the atmospheric pressure. Calculate the pressure at the junction of the tube if the lengths of the tubes are equal. (10 marks)

b) Use simple diagrams to distinguish the terms streamline flow, turbulent flow and tube of flow. (3 marks)

c) Give the mathematical statement of Stokes law. Use the law to deduce the expression for the coefficient of viscosity η of a medium of density δ having a spherical body of radius r and density ρ sinking in it under the influence of the force of gravity. (7 marks)

QUESTION THREE (20 MARKS)

a) Using the relation between the universal gas constant and Boltzmann's constant, calculate the molecular kinetic energy of 1 gas of hydrogen at 0˚C and at 100 ˚C. (5 marks)

b) For pressure of a gas remaining constant calculate the temperature at which its root mean square velocity will be half its value at 0˚C. (6 marks)

c) Deduce the ideal gas equation for one mole of the gas from the kinetic theory of gases. (5 marks)

d) Determine the pressure difference between the inside and outside of a spherical drop of water of radius 1 mm. (Surface tension of water is 73 dynes/cm)? (4 marks)

QUESTION FOUR (20 MARKS)

a) In a sodium chloride material, the spacing between atoms is $a_0 = 5.63\ A^{\circ}$. The interplanar spacing d is given by $d = \frac{a_0}{\sqrt{5}}$. At what angles must an x-ray beam with wavelength of $1.10\ A^{\circ}$ fall on the family of these planes if a diffracted beam is to exist? Up to what order beams can exist and why can the higher orders not exist? (8 marks)

b) A hexagonal system has the base vectors $\overrightarrow{a_1}, \overrightarrow{a_2}$ and $\overrightarrow{a_3}$ where $\overrightarrow{a_1} = \overrightarrow{a_2} \neq \overrightarrow{a_3}$. Calculate the fraction $\frac{a_3}{a_1}$. (9 marks)

c) Briefly differentiate between the three types of solids giving an example of each. (3 marks)

QUESTION FIVE (20 MARKS)

a) For potassium chloride crystal, strong first order reflection of x-rays from the sets of planes (100), (110) and (111) are obtained for angles 5.38˚, 7.62˚ and 9.42˚ respectively. Use the Bragg's law to show that potassium chloride crystal has a simple cubic structure. (8 marks)

b) A capillary tube of radius r is dipped vertically in a liquid whose angle of contact is θ, and it rises to the height h in the tube. Sketch the arrangement, showing clearly the direction of the force of surface tension T. Hence deduce the expression for surface tension T, showing any approximations you have made. (8 marks)

c) A capillary tube of diameter 0.5 mm stands vertically in a vessel containing a liquid of surface tension 30 dynes/cm. The liquid wets the tube and has a specific gravity of 0.8. Calculate the height of the liquid in the tube. (4 marks)