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OFFICE OF THE DEPUTY PRINCIPAL
ACADEMICS, STUDENT AFFAIRS AND RESEARCH

UNIVERSITY EXAMINATIONS

2021 /2022 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER REGULAR EXAMINATION

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: **PHY 222**

COURSE TITLE: **PROPERTIES OF MATTER**

DATE: 8TH JUNE, 2022 **TIME: 0900 – 1200 HRS**

INSTRUCTION TO CANDIDATES

- **SEE INSIDE**

THIS PAPER CONSISTS OF 5 PRINTED PAGES **PLEASE TURN OVER**

Deduce the expression of surface tension, if AB is moved isothermally a distance X to A'B'. (3 Marks)

c) Write down the expression of Poiseuille's law giving the meaning of each term. (2 Marks)

d) Using the equation of state of ideal gases, state the three gas laws (3 Marks)

e) Determine the speed v at which water at $20°C$ sucked up a straw would become turbulent. The straw has diameter of 0.006 m. (2 Marks)

f) Differentiate between shear modulus and bulk modulus. (2 Marks)

SECTION B (42 MARKS)

Question Three (14 Marks)

a) What is the meaning of the following terms that are commonly used in the study of crystal structures

i) Crystal (1 Mark)

ii) Basis (1 Mark)

iii) Lattice parameters (1 Mark)

iv) Bravais lattice (1 Mark)

b) If atoms are considered as contacting hard spheres, show that body-centered cubic (bcc) lattice has a packing fraction of 0.68. (6 Marks)

c) With help of well labelled diagram, describe the following centering types that identify the locations of the lattice points in the conventional unit cell. (4 Marks)

i) Simple
ii) Base-centered (B)
iii) Body-centered (C)
iv) Face-centered (F

Question Four (14 Marks)

a) Using intercepts $(3a, 3b, 2c)$, illustrate the procedure for obtaining the Miller indices that describe a plane in a crystal. (4 Marks)

b) Sketch the following cubic lattice planes (100), (110) and (111). (3 Marks)

REGULAR- MAIN EXAM

PHY 222: PROPERTIES OF MATTER

STREAM: BED SCIENCE **DURATION: 3 Hours**

INSTRUCTIONS TO CANDIDATES

a) *Answer the TWO questions in **SECTION A** and any other **THREE** questions in **SECTION B**.*

b) *The following constants may be useful:*

$1\,eV$	$1.6\times10^{-19}\,J$
Avogadro's number	6.02×10^{23} *molecules/ mole*
Boltzmann's constant, k	1.38×10^{-23} *J/molecule. K*
Density of mercury	*13,600 kg/m3*
Universal gas constant, R	*8.314 J/Mol. K*
1 atm	1.01×10^{5} Pa
1atomic mass unit (u)	$1.66\times10^{-27}\,kg$
Viscosity of water (20°C)	$1.0\times10^{-3}\,N.s/m^2$
Density of water	$1{,}000\,kg/m^3$

SECTION A (28 MARKS)

Question One (14 Marks)

a) With the help of diagrams, distinguish between Van der Waal bonding and Hydrogen bonding. (2 Marks)

b) The net potential energy between two adjacent atoms is sometimes represented by the expression $U=-\frac{A}{r^m}+\frac{B}{r^n}(r>m)$. Derive an expression for the equilibrium bonding energy (U_o) in terms of the equilibrium interionic separation r_o and the constant A. (3 Marks)

c) State three characteristics of non-crystalline solids and give examples of materials with this kind of structure. (4 Marks)

d) Using well labelled 2D lattices, distinguish between rectangular primitive and rectangular centered lattice. (2 Marks)

e) Find the interplanar distance of (200) plane and (111) plane of Nickel crystal (fcc). The radius of Nickel atom is 1.245 Å. (4 Marks)

Question Two (14 Marks)

a) Maxwell speed distribution curves for three different samples of oxygen (O_2) gas is shown in Figure 1.

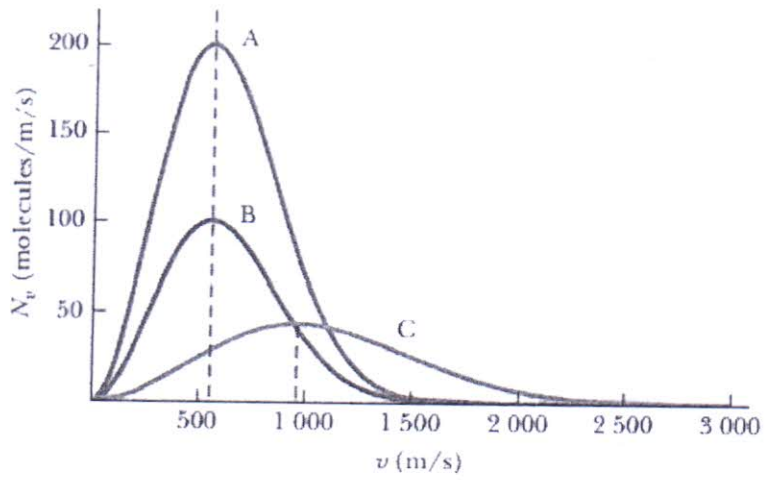

Figure 1: Maxwell Boltzmann distribution for curves at different temperatures.

Rank the temperature of the samples A, B, and C from the highest to the lowest. (2 Marks)

b) Consider stretching a thin film of liquid on a horizontal frame shown in Figure 2. The film has both an upper and lower surface.

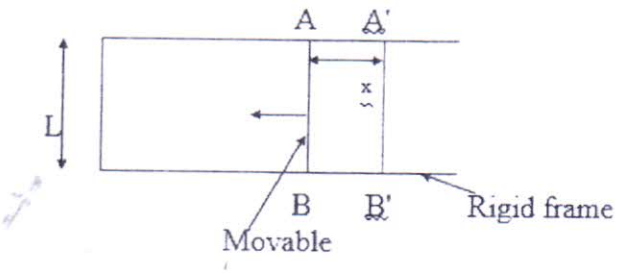

Figure 2

c) Copper (fcc) has density of 8960 kg/m^3. Calculate the lattice constant, a and radius of Cu atom, given the atomic mass of Cu is 63.54 amu. (4 Marks)

d) With the help of well labelled cubic lattices, determine the coordination number of simple cubic, body-centered cubic and face centered cubic. (3 Marks)

Question Five (14 Marks)

a) At what pressure will the mean free path be 50 cm for spherical molecules of radius $3.0\times10^{-10}\ m$? Assume an ideal gas at $20\,°C$. (3 Marks)

b) When 20.9 J was added as heat to a particular ideal gas, the volume of the gas changed from $50.0\,cm^3$ to $100\,cm^3$ while pressure remained constant at 1.00atm.

i) By how much did internal energy of the gas change, if the quantity of gas present was $2.00\times10^{-3}, mol.$? (2 Mark)

ii) determine C_P (2 Marks)

iii) determine C_V (1 Mark)

c) Ten particles are moving with following speeds: four at 200 m/s, two at 500 m/s and four at 600 m/s. Calculate their a) average and b) rms speed of molecules (3 Marks)

d) The most probable speed of the molecules in a gas at temperature T_2 is equal to the rms speed of the molecules at temperature T_1. Find T_2/T_1. (3 Marks)

Question Six (14 Marks)

a) Explain why detergents are added to water to wash clothes or dishes. (2 Marks)

b) With the help of well labelled diagram, show that the height, h to which water would rise in a capillary tube with radius equal to r and contact angle ϕ is $h=\frac{2\gamma}{\rho g r}\cos\phi$. Assume density, surface tension and mass of water is ρ, γ and M, respectively. (4 Marks)

c) State any two useful effects of capillary action. (2 Marks)

d) State the following principles relating to fluid flow: *i)* principle of continuity *ii)* Bernoulli's theorem. (2 Marks)

e) Water is moving with speed of 5.0 m/s through a pipe with a uniform cross-sectional area of $4.0\,cm^2$. The water gradually descends 10m as the pipe cross-sectional area increases to 8.0 cm^2.

i) What is the speed at the lower level (2 Marks)

ii) If the pressure at the upper level is $1.5\times10^5\ Pa$, what is the pressure at the lower level? (3 Marks)

Question Seven (14 Marks)

a) State Bragg's law. (1 Mark)

b) The Bragg's angle for (220) reflection from nickel (fcc) is 38.2° when x-rays of wavelength 1.54Å are employed in a diffraction experiment. Determine the lattice constant, a of nickel. (3 Marks)

c) With the help of well labelled diagrams, state the differences between Laue's method, the rotating crystal method and the powder method of x-ray diffraction? (3 Marks)

d) The bulk modulus of water is 2.1 GPa ($2.1\times10^9\ Pa$). Compute the volume contraction of 100 mL of water subjected to a pressure of $1.5\times10^6\ Pa$. (2 Marks)

e) A box-shaped piece of gelatin desset has a top area of $15\,cm^2$ and a height of 3.0 cm. When a shearing force of 0.5 N is applied to the upper surface, the upper surface displaces 4.0 mm relative to the bottom surface. What are the shearing stress, the shearing strain, and the shear modulus of the gelatin. (3 Marks)

f) A 200kg- load is hung on a wire of length 4.00 m, cross-sectional area $0.2\times10^{-4}\ m^2$, and Young modulus $8.00\times10^{10}\ N/m^2$. What is its increase in length? (2 Marks)