

PHY 222



ALUPE UNIVERSITY
OFFICE OF THE DEPUTY VICE CHANCELLOR
ACADEMICS, RESEARCH AND STUDENTS AFFAIRS

UNIVERSITY EXAMINATIONS

2024 /2025 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER REGULAR MAIN
EXAMINATION

FOR THE DEGREE OF BACHELOR OF
EDUCATION SCIENCE

COURSE CODE: PHY 222

COURSE TITLE: PROPERTIES OF MATTER

DATE: 07/04/2025

TIME: 2 PM - 5 PM

INSTRUCTION TO CANDIDATES

- **SEE INSIDE**

THIS PAPER CONSISTS OF 6 PRINTED PAGES

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REGULAR- MAIN EXAM**PHY 222: PROPERTIES OF MATTER**

STREAM: BED (Scie.)

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

SECTION A (24 MARKS)**Question One (12 Marks)**

- a) What is the difference between covalent bonding, metallic bonding and hydrogen bonding? (3 Marks)
- b) Briefly describe the nature of forces existing between atoms in a crystal. (2 Marks)
- c) The rms speed of nitrogen molecules in the air at 1 atm and 27°C is about 490 m/s. Find their mean free path and the average time between collisions. The radius of a nitrogen molecule can be taken to be $2 \times 10^{-10} \text{ m}$. (4 Marks)
- d) Write Van der Waal's equation of state and highlight how Van der Waal took into account attractive forces between the molecules as well as the volume of the molecules. (3 Marks)

Question Two (12 Marks)

- a) What is the meaning of the following terms used in crystallography
- Basis (1 Mark)
 - Unit cell (1 Mark)
 - Bravais lattice (1 Mark)
 - Coordination number (1 Mark)
- b) Find the volume of unit cell of lead (FCC). The radius of $Pb = 0.175 \text{ nm}$. (2 Marks)

- c) What is the difference between streamline flow and turbulent flow (2 Marks)
- d) A patient receives a blood transfusion through a needle of radius 0.20 mm and length 2.0 cm. The density of blood is 1050 kg/m^3 . If the pressure difference is $5,145 \text{ N/m}^2$, what is the rate of flow through the needle? (2 Marks)
- e) A horizontal aluminium rod 4.8 cm in diameter projects 5.3cm from a wall. A 1200 kg object is suspended from the end of the rod. The shear modulus of aluminium is $3.0 \times 10^{10} \text{ N/m}^2$. Find the shear stress on the rod? (2 Marks)

SECTION B (36 MARKS)

Question Three (12 Marks)

- a) Consider a bcc unit cell with metallic radius of 1.00 \AA
- Determine the volume of the atoms contained in one unit cell (1 Mark)
 - What is the length of one edge of the unit cell (2 Marks)
 - What is the volume of the unit cell (1 Mark)
 - Determine atomic packing factor of this bcc unit cell (2 Marks)
- b) Draw the following planes and directions in the case of *FCC* structure: (112) , (001) and (101) . (6 Marks)

Question Four (12 Marks)

- a) What characteristics distinguish a crystalline solid from an amorphous solid? (4 Marks)
- b) Differentiate between simple cubic (sc) and face centred cubic (fcc) unit cell in terms of their atomic packing fraction and coordination number. (2 Marks)
- c) Rhodium (*FCC*) has an atomic radius of 0.1345 nm and atomic weight of 102.91 g/mol. Determine Rhodium density. (4 Marks)
- d) Draw hexagonal and oblique 2D lattices and state their unit cell characteristics. (2 Marks)

Question Five (12 Marks)

- a) A container is filled with nitrogen gas molecules (N_2 , molar mass 28.0 g/mol) at $T = 0^\circ \text{C}$. Calculate i) the most probable speed v_{mp} ; ii) the average speed v_{av} ; iii) the root mean square speed v_{rms} . (6 Marks)
- b) Under constant pressure, the temperature of 2.00 mol of an ideal monatomic gas is raised 15.0 K. What are
- the work W done by the gas, (2 Marks)
 - the energy transferred as heat Q , (2 Marks)

- iii) the change in the internal energy of the gas (2 Marks)

Question Six (12 Marks)

- a) State three factors that affect surface tension. (3 Marks)
- b) Whole blood has a surface tension of 0.058 N/m and a density of 1050 kg/m^3 . To what height can whole blood rise in a capillary blood vessel that has a radius of $2.0 \times 10^{-6} \text{ m}$ if the contact angle is zero? (3 Marks)
- c) A pipe has diameter of 16 cm at section 1 and 10 cm at section 2. At section 1 the pressure is 200 kPa . Point 2 is 6.0 cm higher than point 1. When oil of density 800 kg/m^3 flows at a rate of $0.03 \text{ m}^3/\text{s}$, find pressure at point-2 if viscous effects are negligible. (5 Marks)
- d) With help of a well labelled diagram indicating forces acting on a sphere, (radius, r and density, ρ) falling in a fluid density, σ , deduce the equation of net driving force when the body attains terminal velocity. (1 Mark)

Question Seven (12 Marks)

- a) Calculate the Bragg angle if (111) planes of a cube ($a = 3.75 \text{ \AA}$) crystal are exposed to X-rays (wavelength = 1.54 \AA) (4 Marks)
- b) A solid copper cube has an edge length of 85.5 cm . How much stress must be applied to the cube to reduce the edge length to 85.0 cm ? The bulk modulus of copper is $1.4 \times 10^{11} \text{ N/m}^2$. (3 Marks)
- c) After a fall, a 95 kg rock climber finds himself dangling from the end of a rope that had been 15 m long and 9.6 mm in diameter but has stretched by 2.8 cm . For the rope, calculate
- the strain, (1 Mark)
 - the stress, and (2 Marks)
 - the Young's modulus. (2 Marks)